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Das et al.

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(54) **INJECTOR NOZZLE QUENCHING PROCESS FOR PIPING SYSTEMS**

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(73) Assignee: **PHILLIPS 66 COMPANY**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 626 days.

This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**

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B01F 5/04	(2006.01)
F28C 3/00	(2006.01)
B01F 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***C21D 9/085*** (2013.01); ***B01F 5/0461*** (2013.01); ***F28C 3/00*** (2013.01); *B01F 2005/0034* (2013.01)

(58) **Field of Classification Search**

CPC B01F 5/0451; B01F 5/465; B01F 5/471; B01F 5/473; B01F 5/0465; B01F 5/0471; B01F 5/0473

USPC 366/158.5, 167.1, 173.2, 175.2, 181.5, 366/336–337; 261/76

See application file for complete search history.

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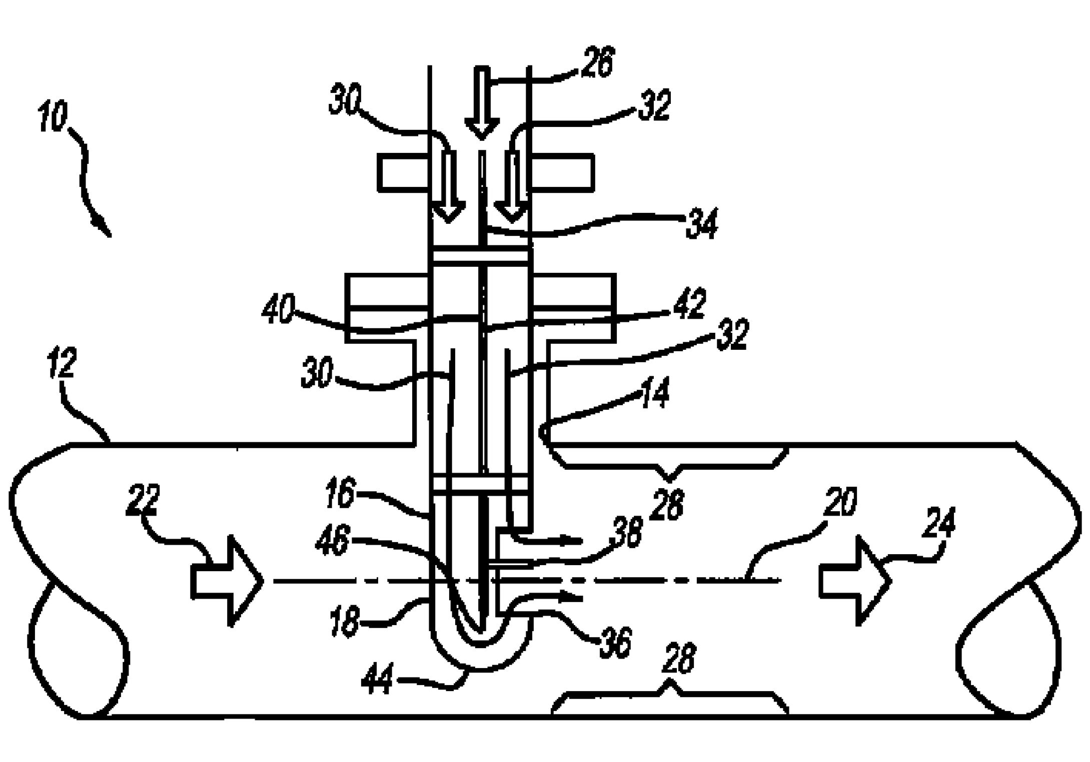
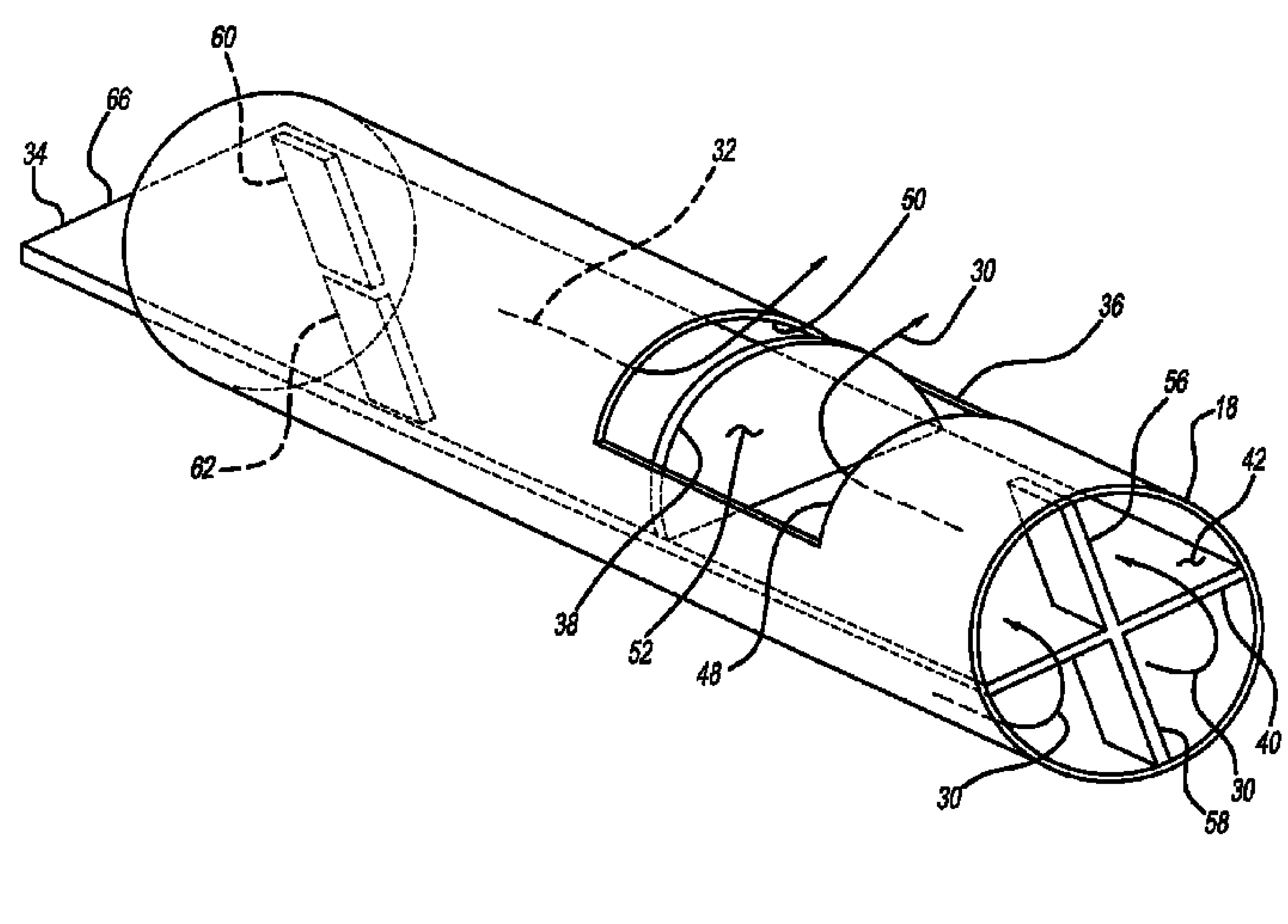
(57) **ABSTRACT**

A quenching process for quenching a flowing first fluid with a flowing second fluid may involve a first hollow pipe for containing the flowing first fluid and a second hollow pipe for containing the flowing second fluid; dividing the flowing second fluid into a first baffle flow along a first side of a longitudinal baffle and a second baffle flow along a second side of the longitudinal baffle within the second hollow pipe; providing a transverse baffle protruding from the longitudinal baffle for directing the first baffle flow from a first baffle flow outlet and the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the flowing first fluid in the first hollow pipe; and configuring an area of the first baffle flow outlet area to be greater than or equal to an area of the second baffle flow outlet area.

12 Claims, 10 Drawing Sheets





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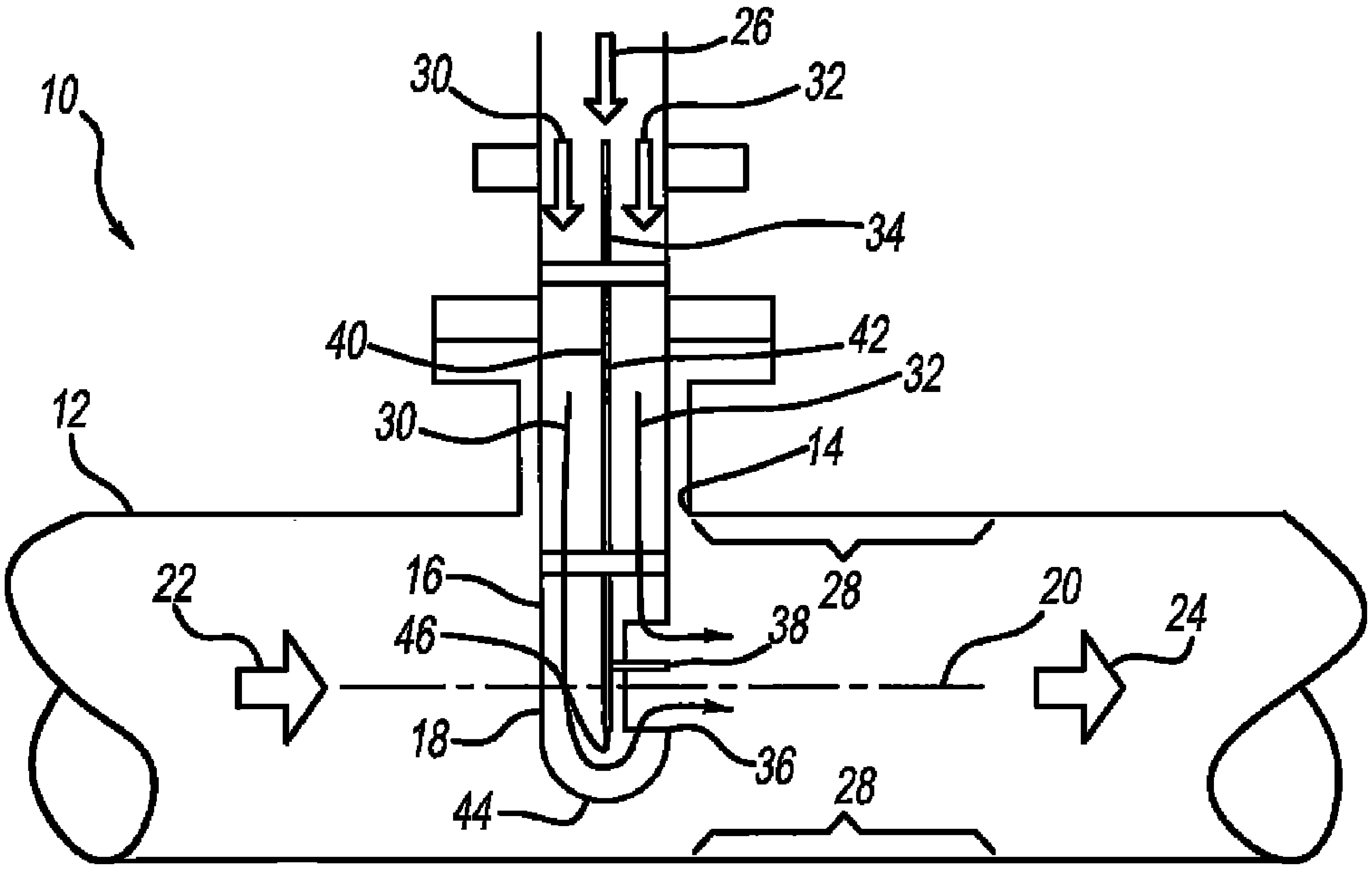
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30
26
32
34
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22
46
38
20
24
18
36
44
28

FIG - 1

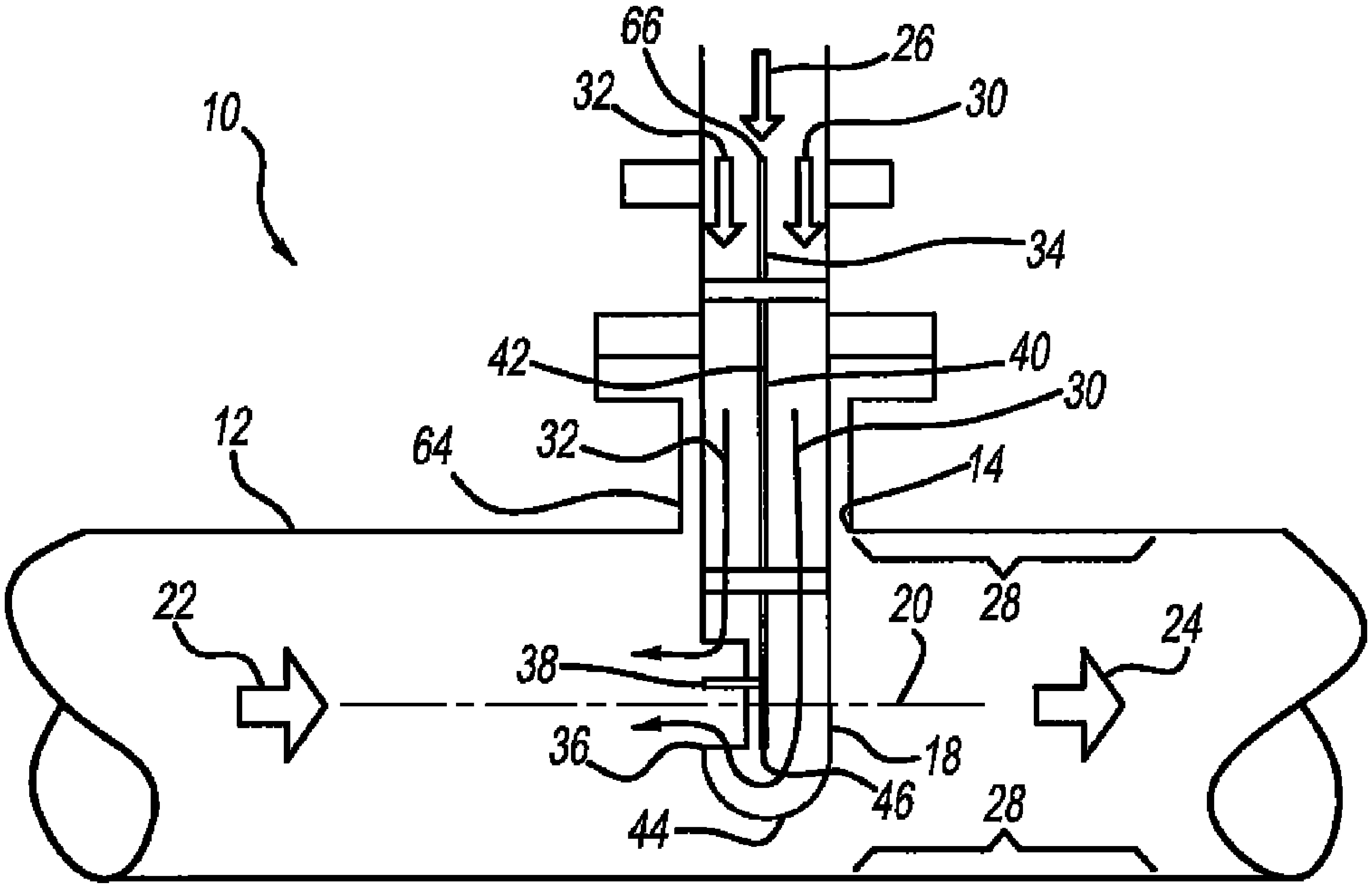

66
26
32
30
10
34
42
40
30
12
64
32
14
28
22
20
24
38
36
18
46
44
28

FIG - 2

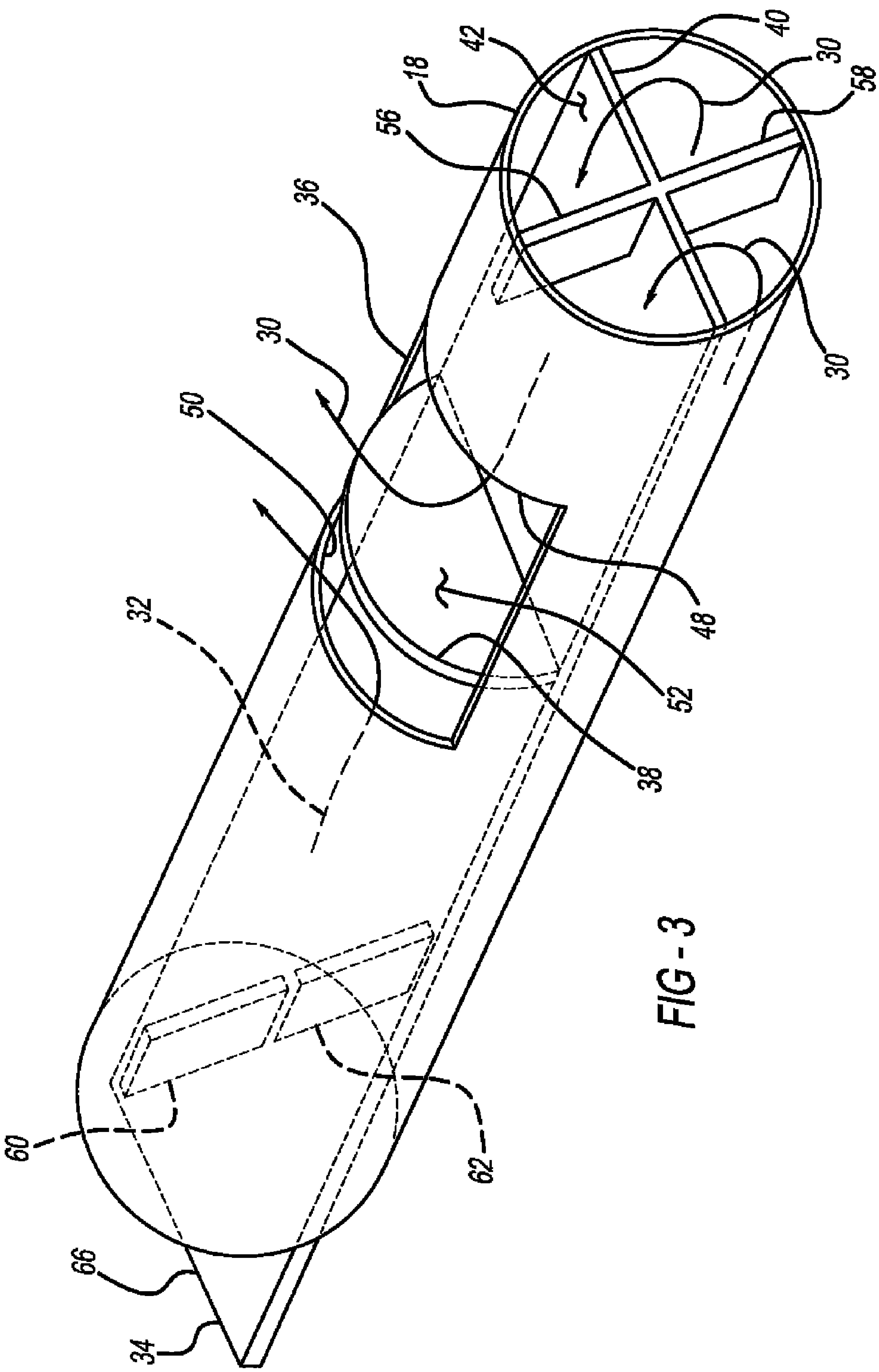


FIG - 3

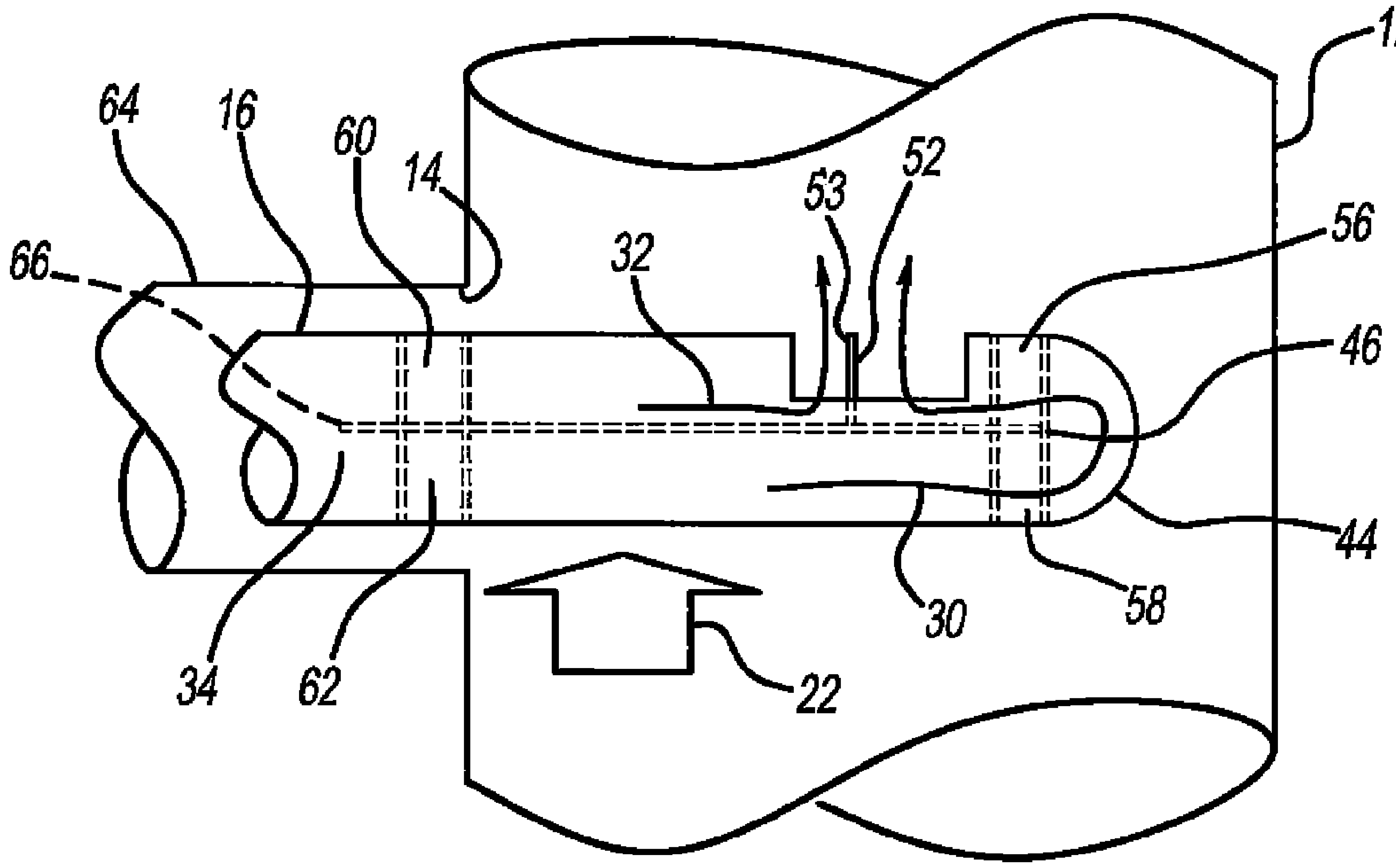

12
64
16
60
14
53
52
56
66
32
46
44
34
62
22
30
58

FIG - 4

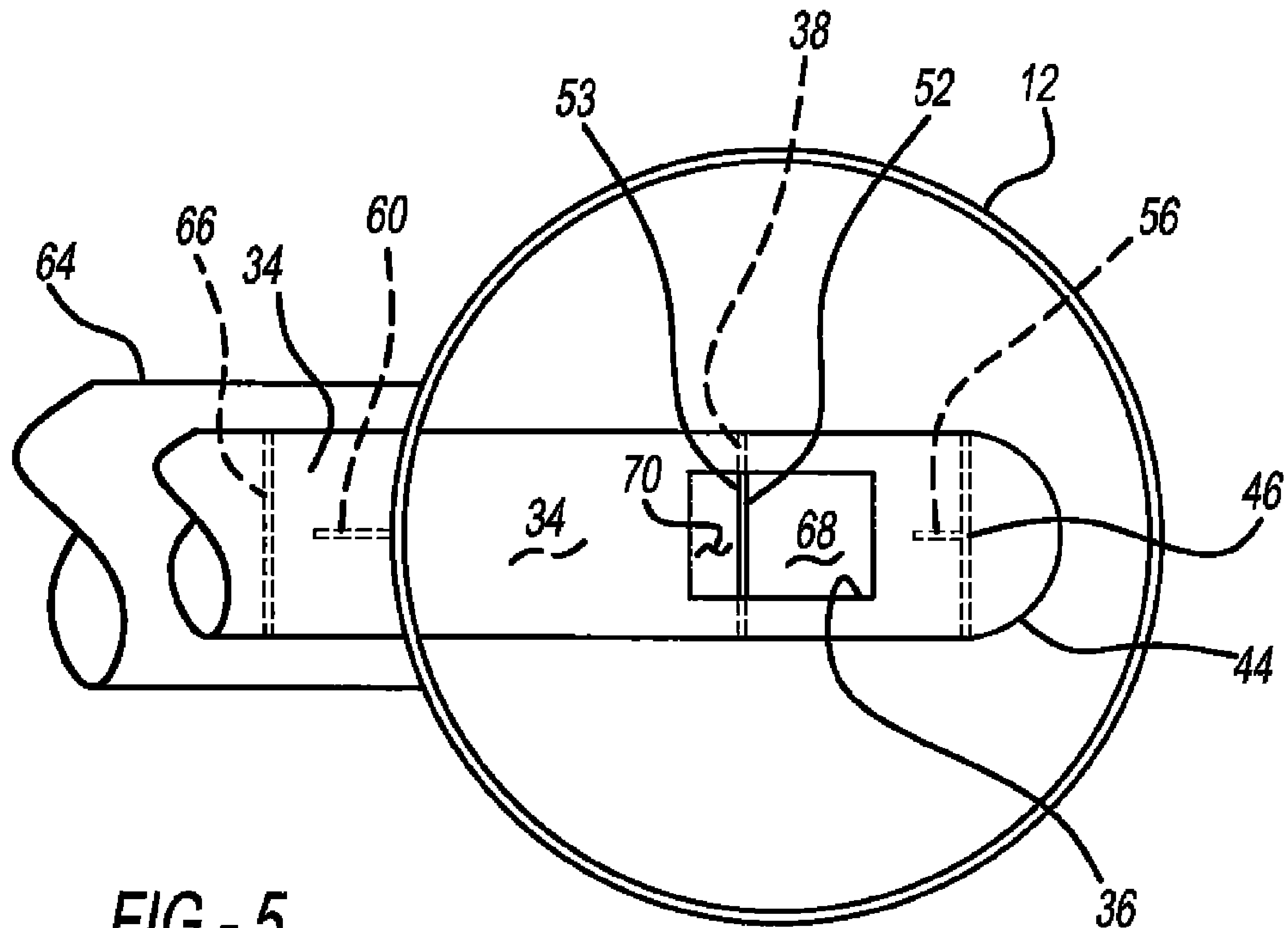

38
53
52
12
66
60
56
64
34
70
34
68
46
44
36

FIG - 5

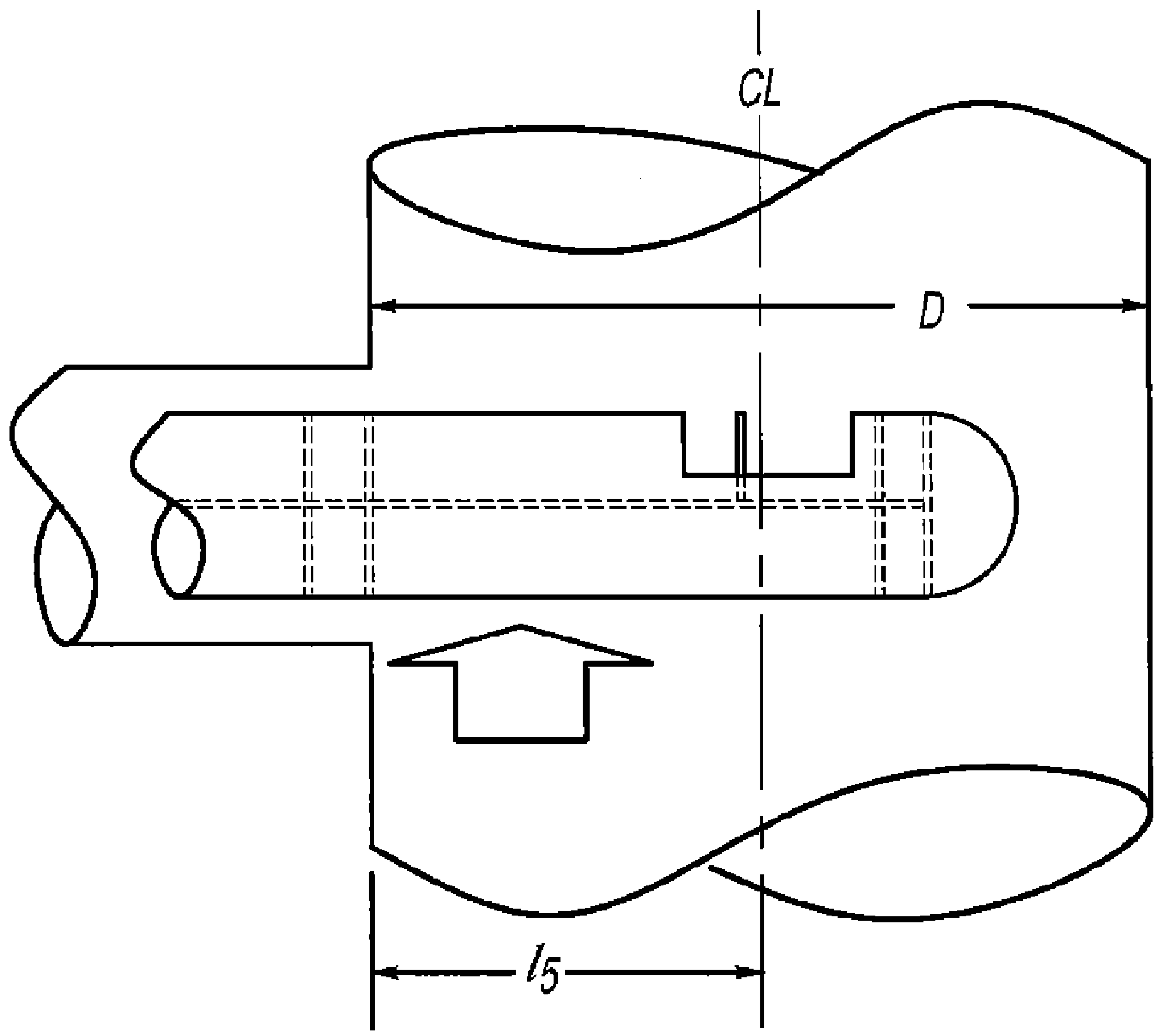


FIG - 6

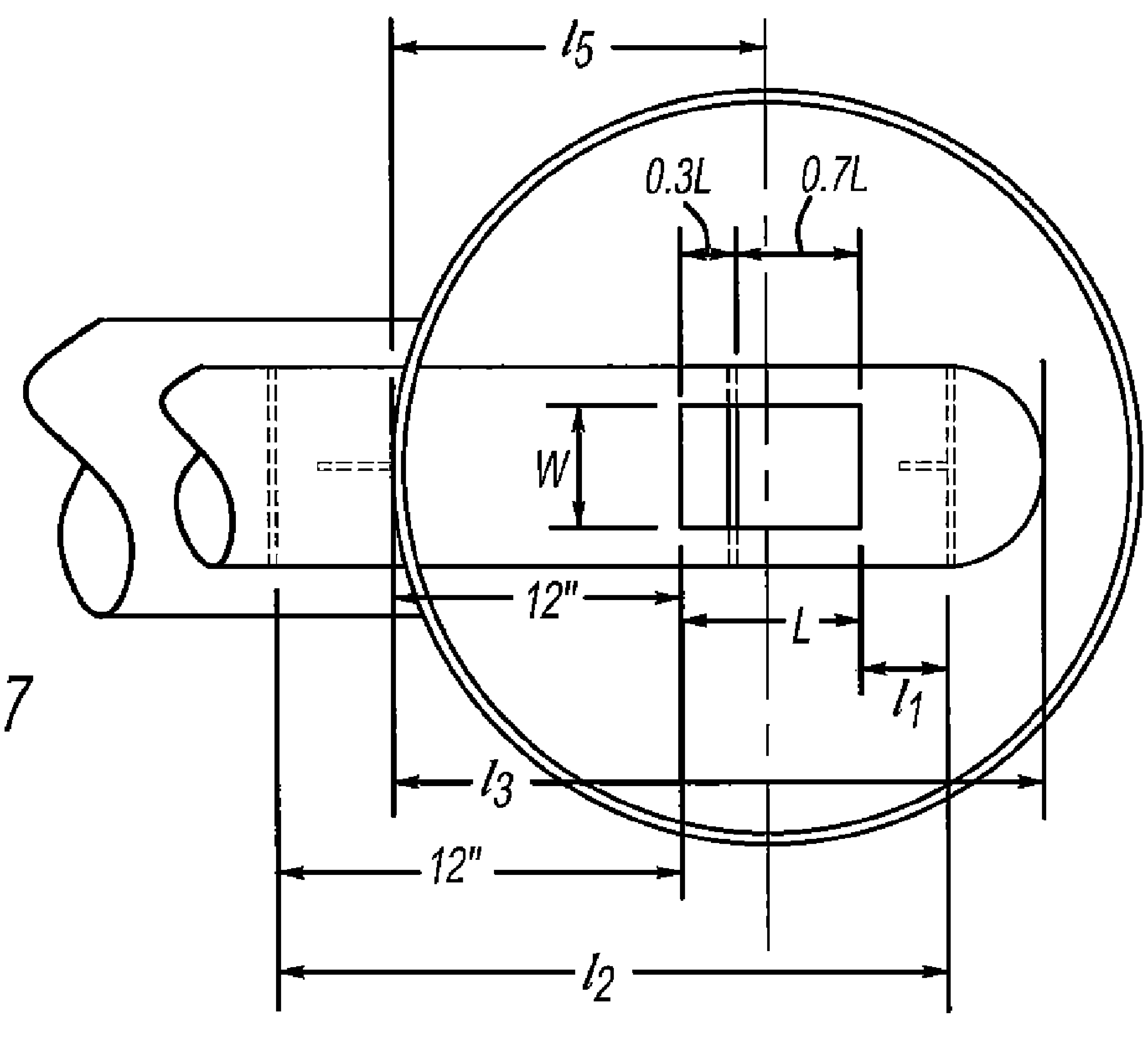


FIG - 7

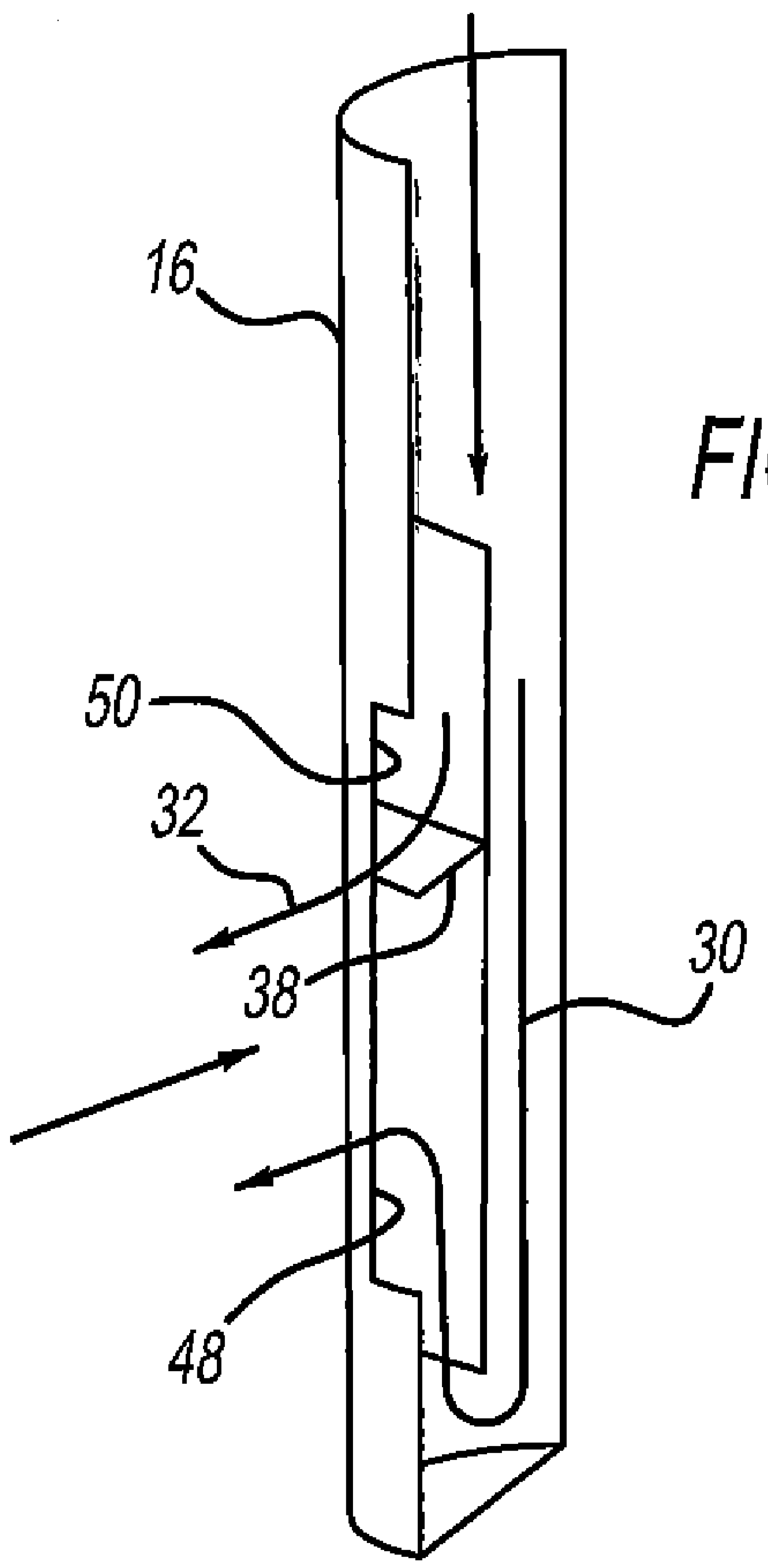


FIG - 8A

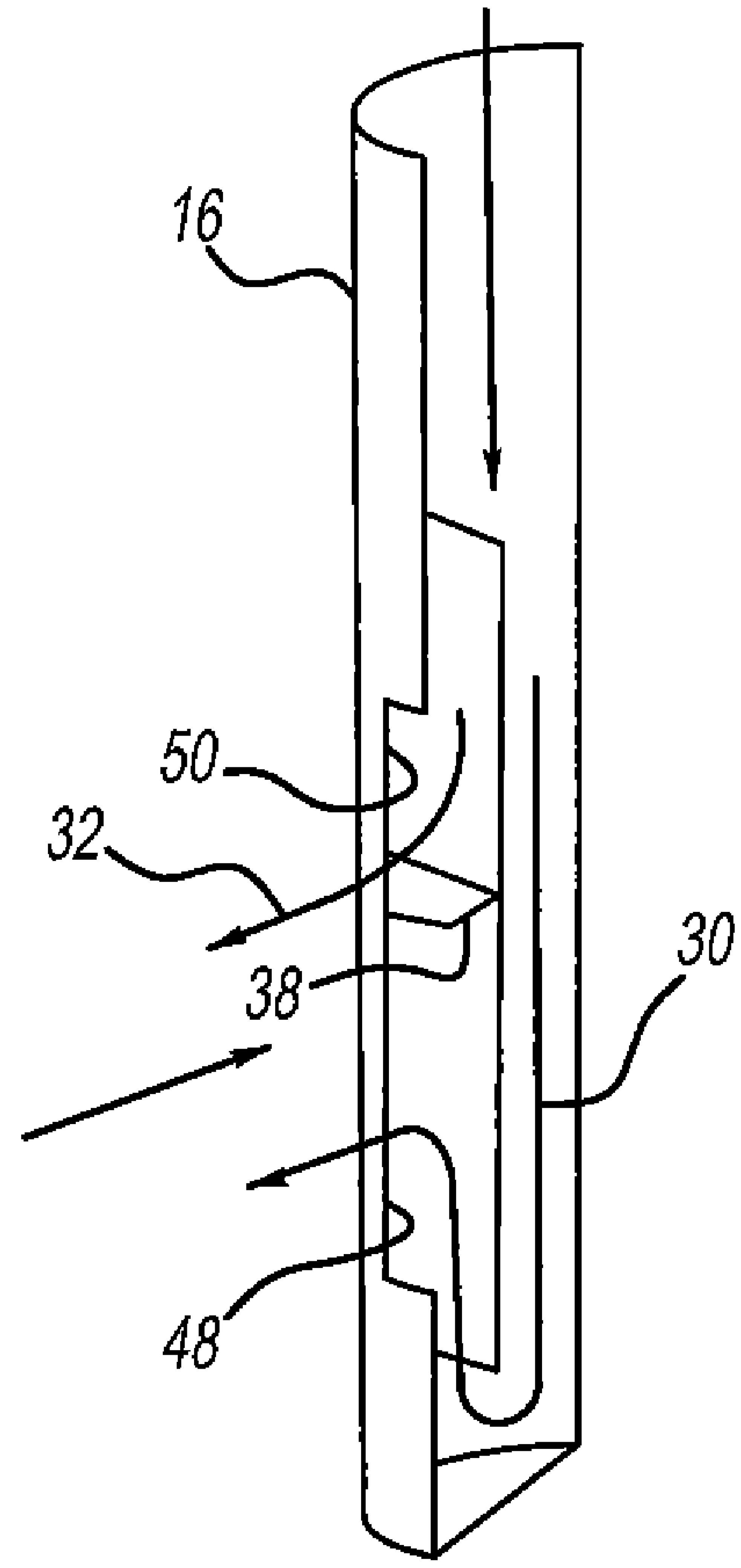


FIG - 8B

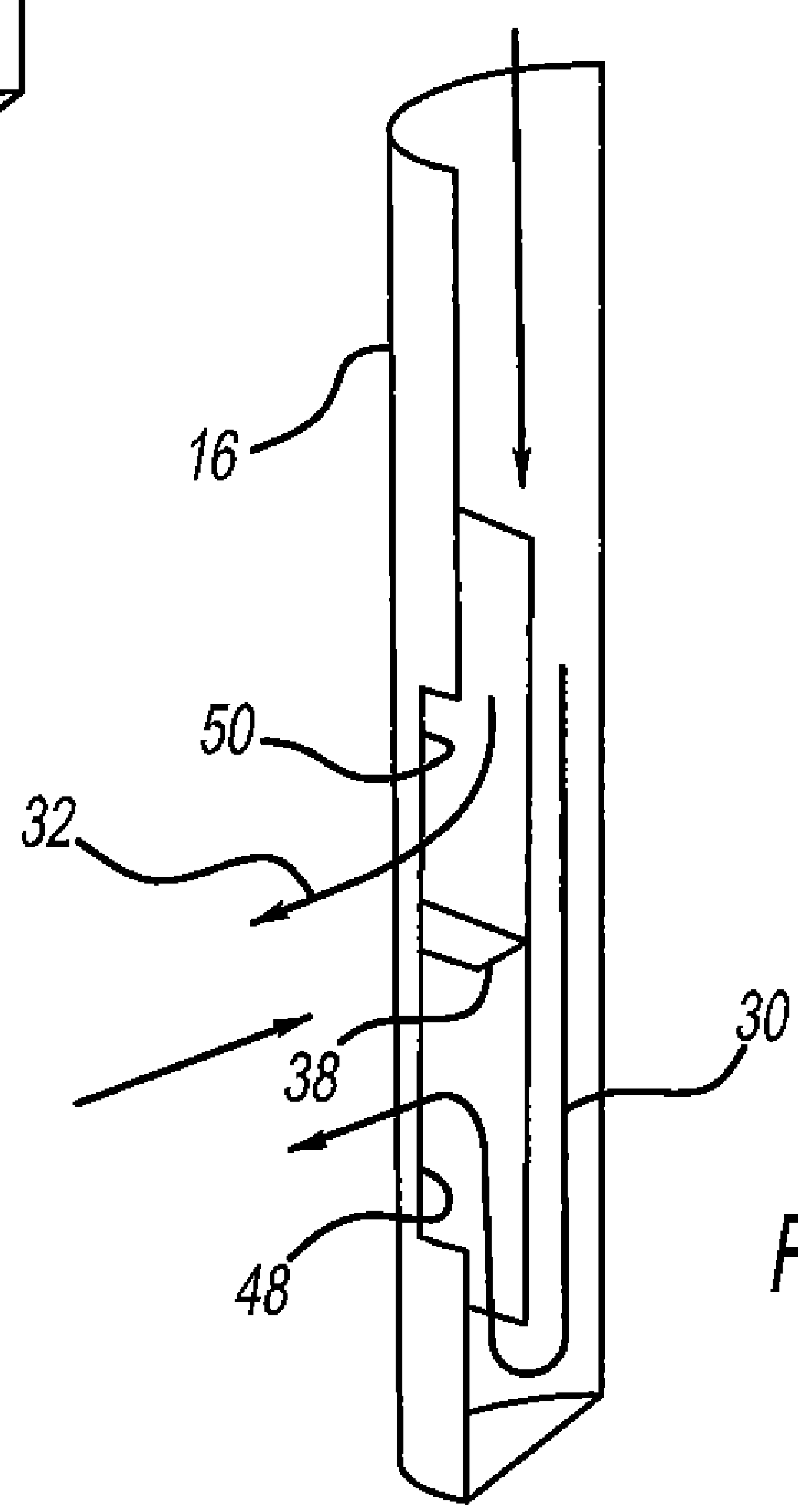


FIG - 8C

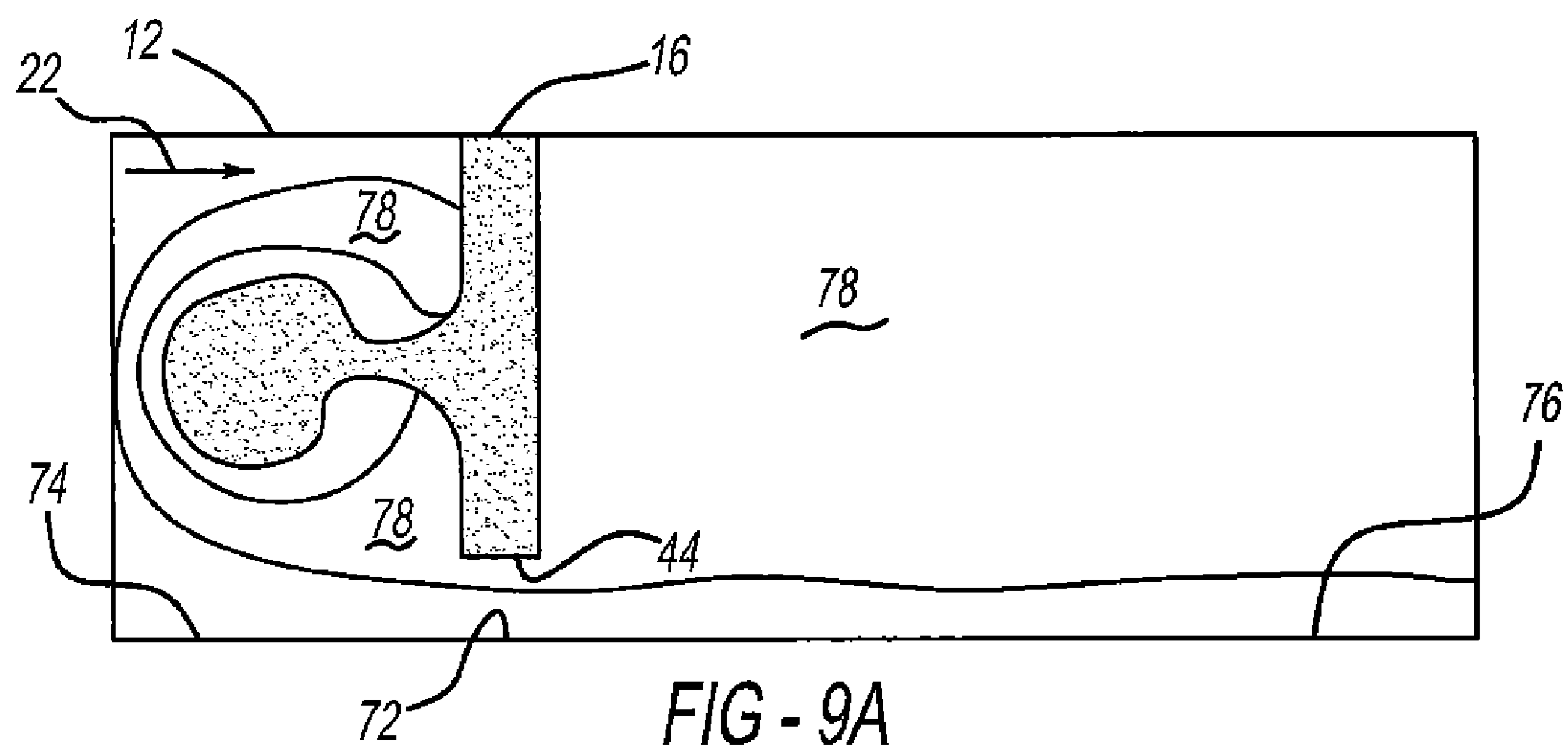


FIG - 9A

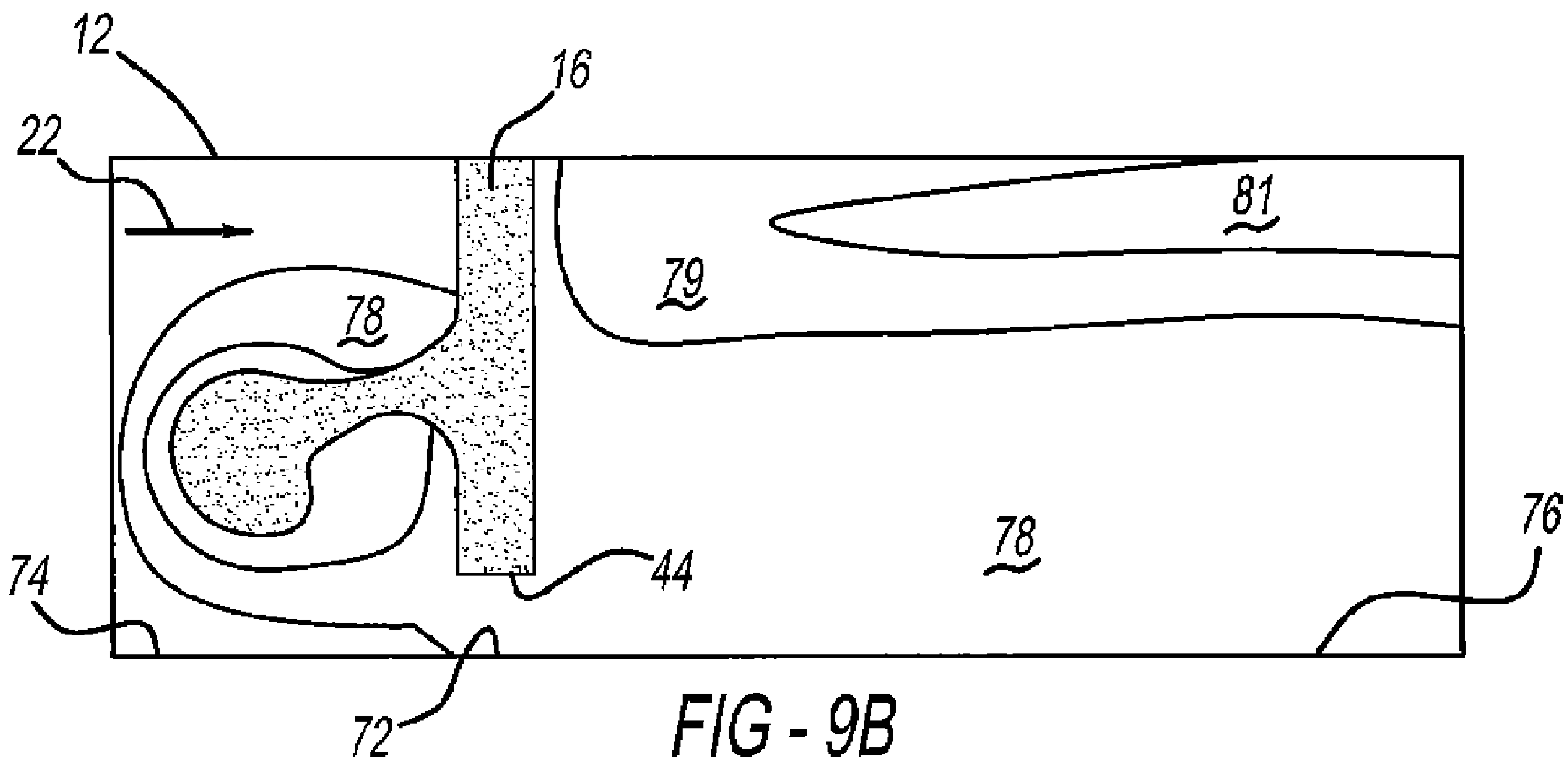


FIG - 9B

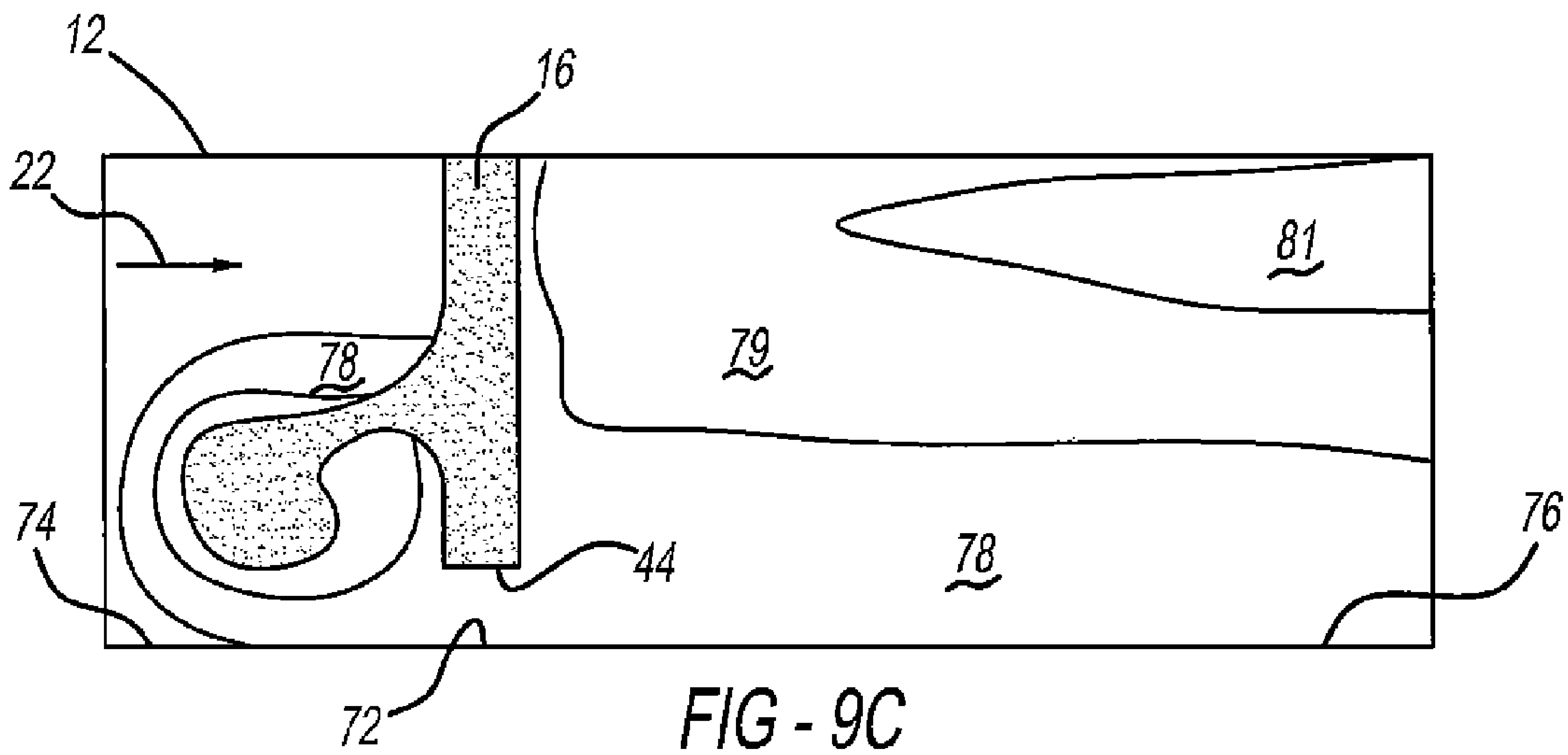


FIG - 9C

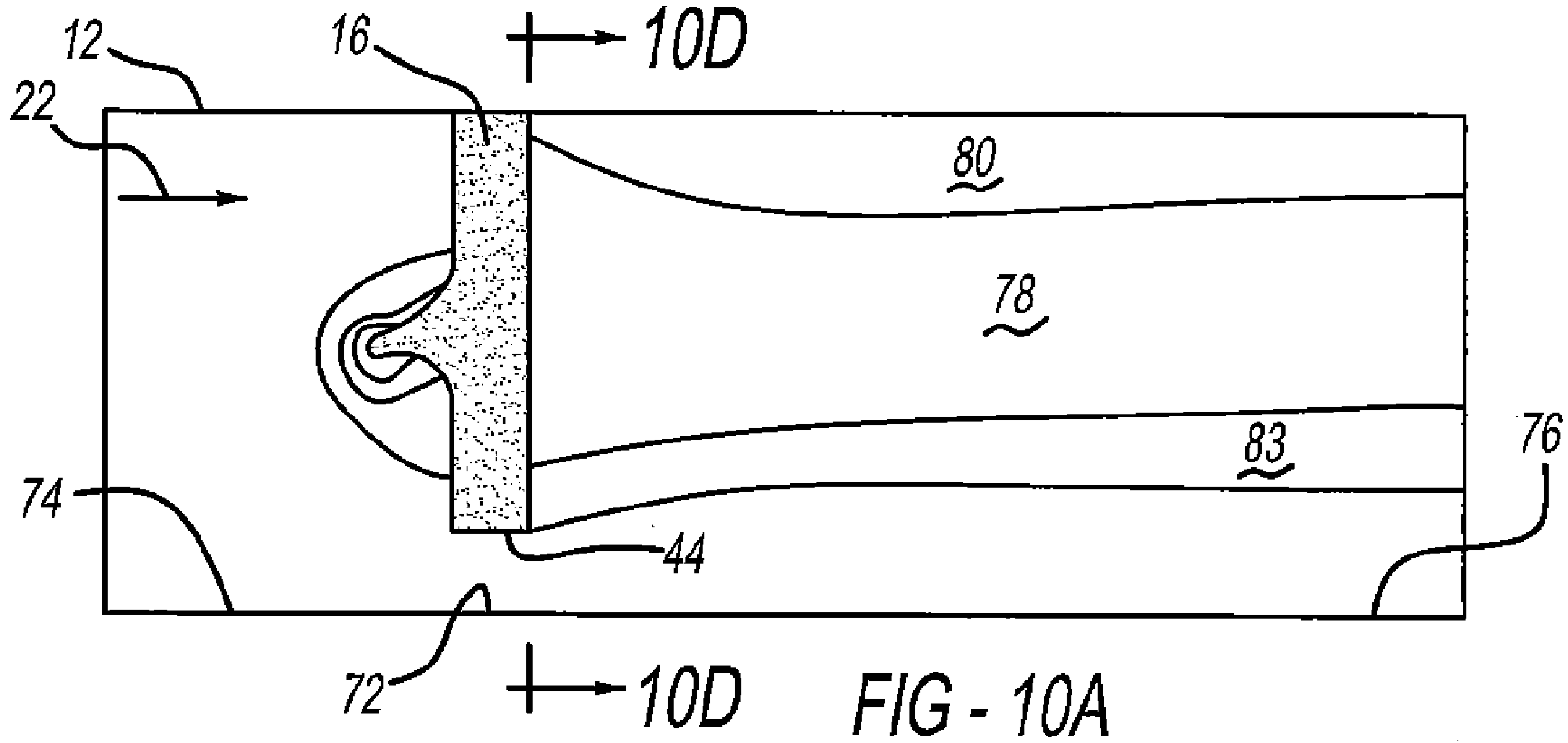


FIG - 10A

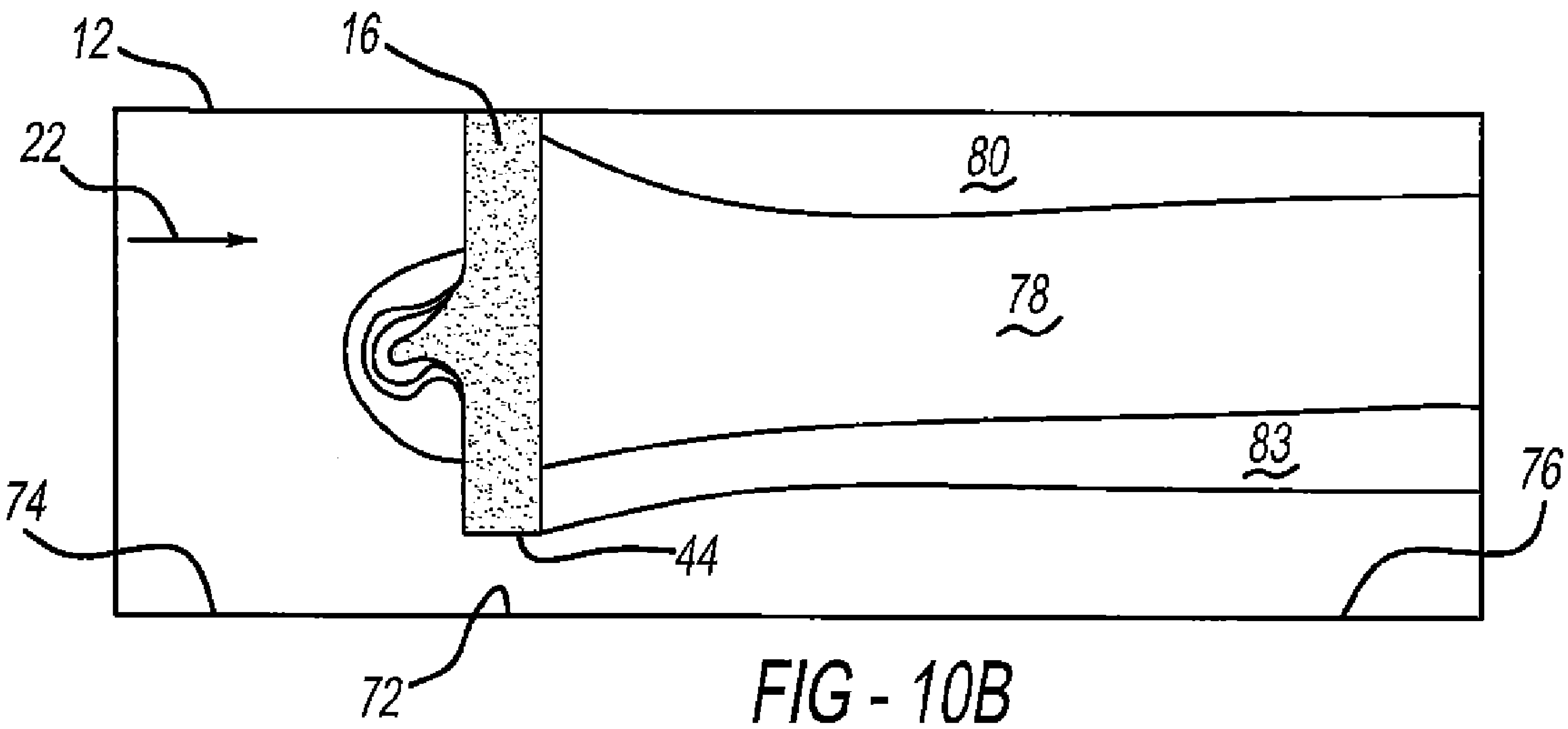


FIG - 10B

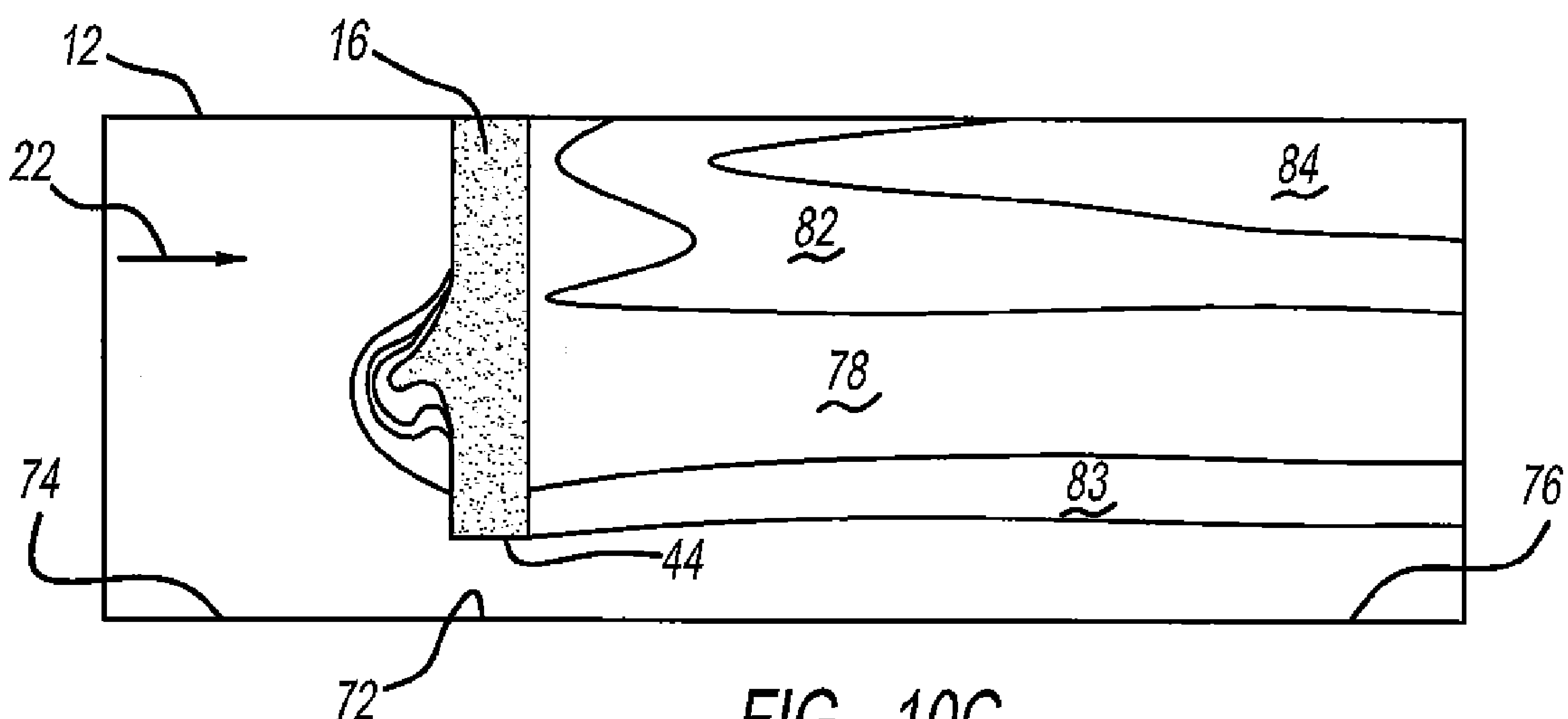


FIG - 10C

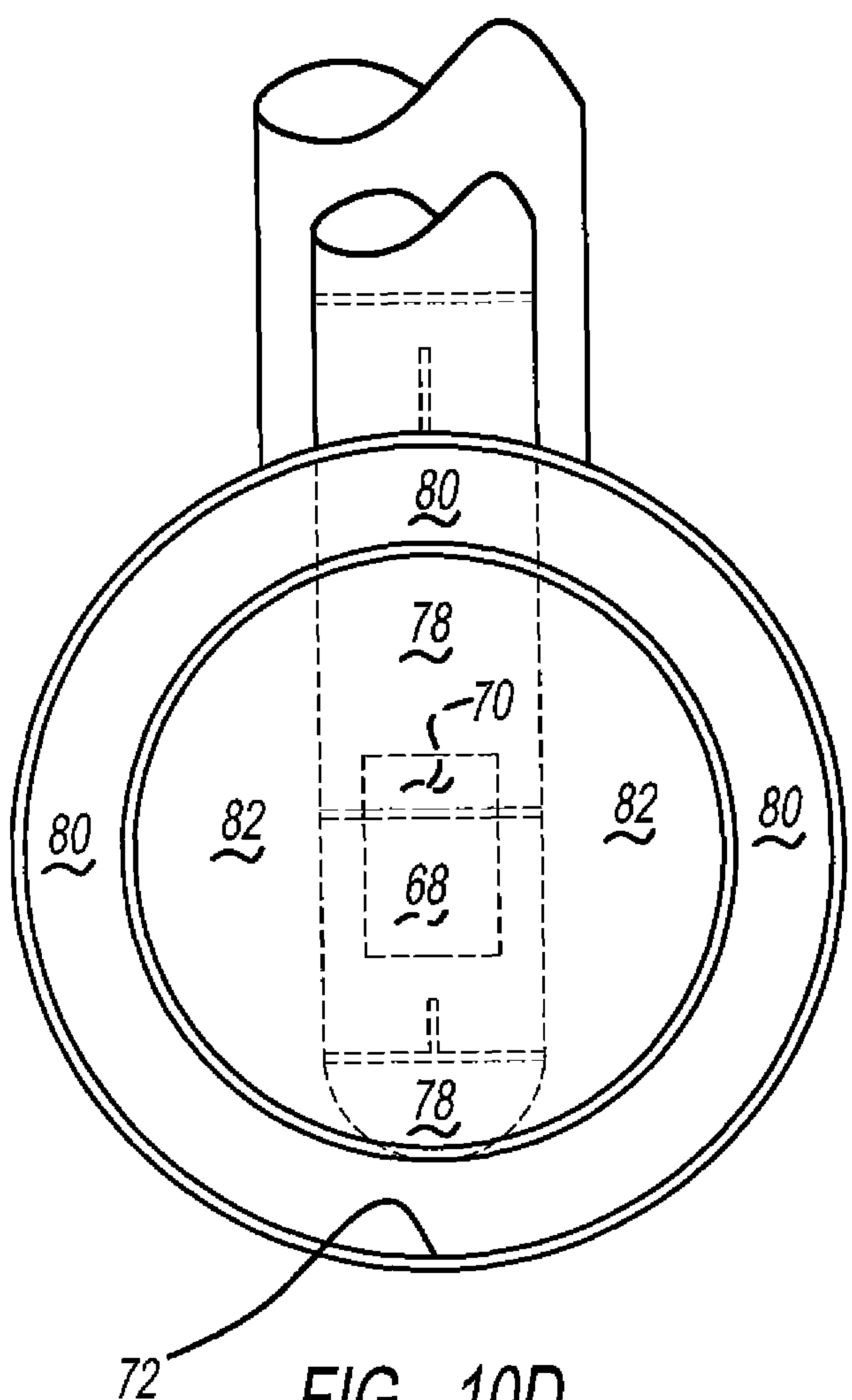


FIG - 10D

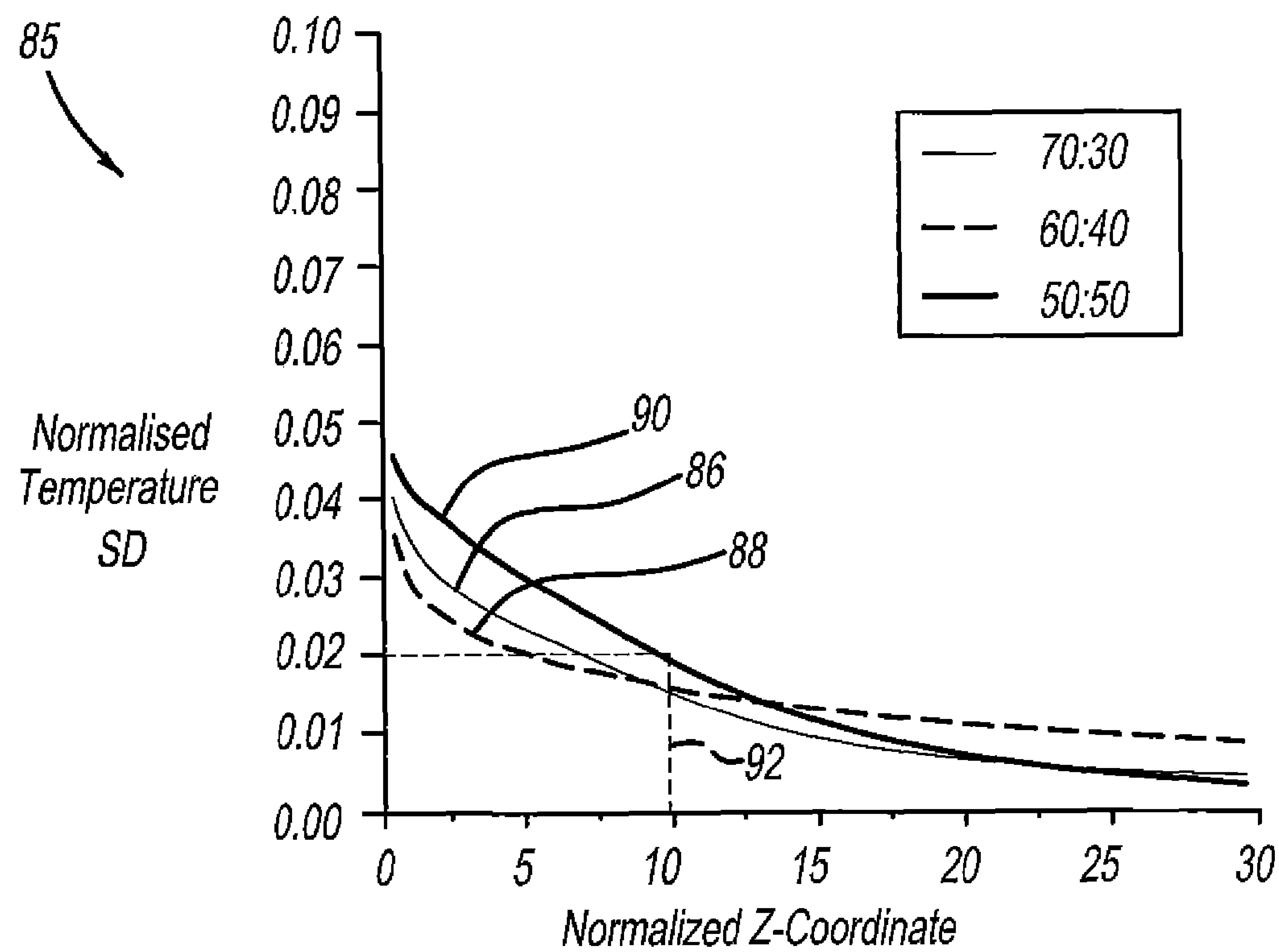
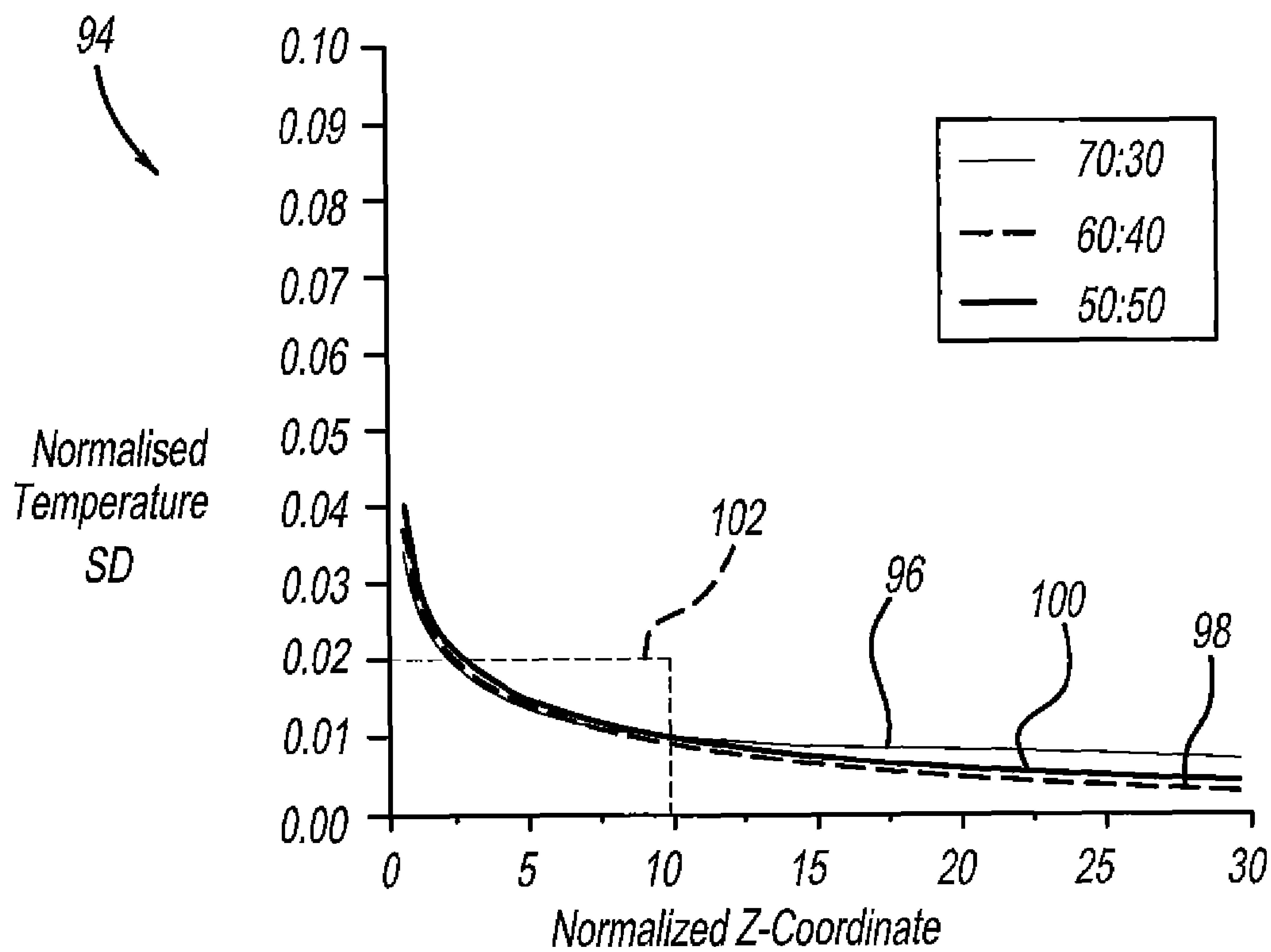

85
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Normalised Temperature SD
70:30
60:40
50:50
90
86
88
92
0
5
10
15
20
25
30
Normalized Z-Coordinate

FIG - 11


94
0.10
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0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Normalised Temperature SD
70:30
60:40
50:50
102
96
100
98
0
5
10
15
20
25
30
Normalized Z-Coordinate

FIG - 12

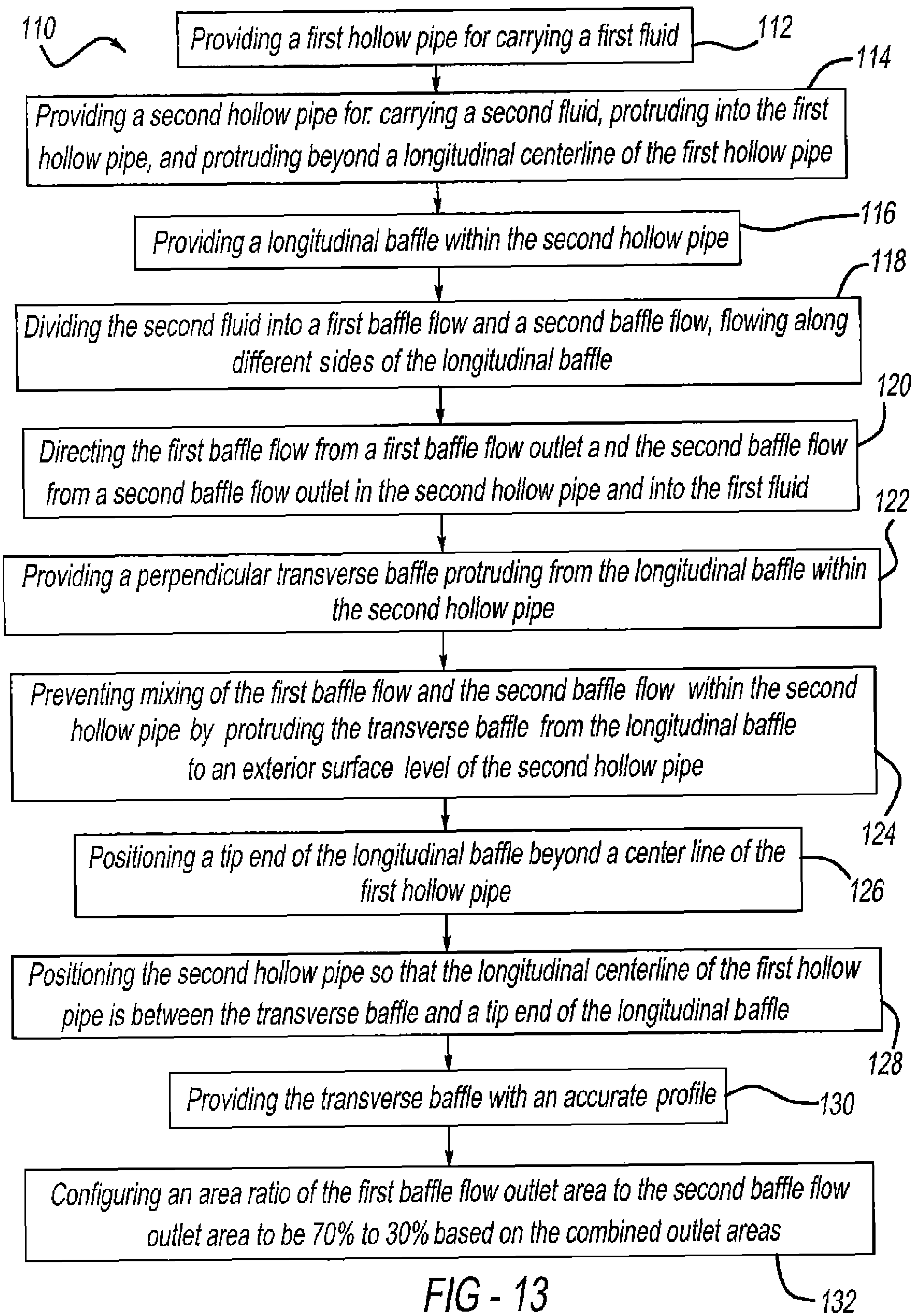
110
Providing a first hollow pipe for carrying a first fluid
112
Providing a second hollow pipe for. carrying a second fluid, protruding into the first hollow pipe, and protruding beyond a longitudinal centerline of the first hollow pipe
114
Providing a longitudinal baffle within the second hollow pipe
116
Dividing the second fluid into a first baffle flow and a second baffle flow, flowing along different sides of the longitudinal baffle
118
Directing the first baffle flow from a first baffle flow outlet a nd the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the first fluid
120
Providing a perpendicular transverse baffle protruding from the longitudinal baffle within the second hollow pipe
122
Preventing mixing of the first baffle flow and the second baffle flow within the second hollow pipe by protruding the transverse baffle from the longitudinal baffle to an exterior surface level of the second hollow pipe
124
Positioning a tip end of the longitudinal baffle beyond a center line of the first hollow pipe
126
Positioning the second hollow pipe so that the longitudinal centerline of the first hollow pipe is between the transverse baffle and a tip end of the longitudinal baffle
128
Providing the transverse baffle with an accurate profile
130
Configuring an area ratio of the first baffle flow outlet area to the second baffle flow outlet area to be 70% to 30% based on the combined outlet areas
132

FIG - 13

INJECTOR NOZZLE QUENCHING PROCESS FOR PIPING SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a non-provisional application which claims benefit under 35 USC§119(e) to U.S. Provisional Application Ser. No. 61/692,805 filed Aug. 24, 2012, entitled INJECTOR NOZZLE FOR QUENCHING WITHIN PIPING SYSTEMS, which is incorporated herein in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

None.

FIELD OF THE INVENTION

This invention relates to an injector nozzle quenching process for piping systems.

BACKGROUND OF THE INVENTION

Piping systems in a variety of industrial settings are used to transport liquids and gases over a broad range of temperatures. In such piping systems, mixing of fluids of two different fluid streams may be necessary. In one example piping system, a first fluid at a first temperature in a first pipe may be continuously mixed with a second fluid at a second temperature in a second pipe to achieve a prescribed or desired mixing effectiveness. The temperature difference between the first fluid and the second fluid may be relatively large, and in some situations, mixing may actually be an injection of the first fluid in the first pipe into the second fluid in the second pipe. Because of the relatively large temperature differential that may exist between the first fluid and the second fluid, when such mixing or injecting occurs, a large temperature differential may be created within the pipe wall of the pipe receiving the injection of fluid. A relatively large temperature differential may result in unnecessary pipe repairs or replacements due to thermal stressing of the metal from which the pipe is constructed. To prevent the pipe wall of the pipe receiving the fluid injection from experiencing relatively large temperature fluctuations, improvement is needed. What is needed then is a device and method that permits maintaining a relatively small or no temperature differential along pipe wall sections in pipes that receive fluid injections at and near the location of the injections, without compromising mixing effectiveness of an injected fluid into a receiving fluid.

BRIEF SUMMARY OF THE DISCLOSURE

A quenching process may include providing a first hollow pipe for containing a flowing first fluid and a second hollow pipe for containing a flowing second fluid. The second fluid may be contained as a single flow upstream of a longitudinal baffle within the second hollow pipe. The longitudinal baffle within the second hollow pipe functions for dividing the flowing second fluid into a first baffle flow along a first surface or side of the longitudinal baffle and a second baffle flow along a second surface or side of the longitudinal baffle. Providing a transverse baffle that protrudes from the longitudinal baffle further directs the first baffle flow and the second baffle flow into the first fluid of the first pipe for

mixing and creating thermal advantages. Providing the transverse baffle with two parallel surfaces that are perpendicular to opposite side surfaces of the longitudinal baffle further permits the transverse baffle to reside protruding from the longitudinal baffle and function in directing the first baffle flow from a first baffle flow outlet and the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the first fluid in the first hollow pipe. The first baffle flow outlet may have a first baffle flow outlet area and the second baffle flow outlet may have a second baffle flow outlet area that together equal a total outlet area for the two baffle flows. Providing the transverse baffle with an exterior partial peripheral arcuate profile that is geometrically the same arcuate shape as an exterior peripheral profile of the first hollow pipe permits easy insertion of the transverse baffle inside the second hollow pipe from an end of the second hollow pipe during manufacturing and permits flow characteristics of the first fluid to be maintained when the second hollow pipe is functioning within the first hollow pipe as an injection pipe. The discharge outlet areas of the second hollow pipe may be constructed such that configuring an area of the first baffle flow outlet area may be greater than or equal to an outlet area of the second baffle flow outlet area.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention and benefits thereof may be acquired by referring to the follow description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a side view of an injector nozzle and main pipe arrangement depicting a co-current injection arrangement of the injector nozzle with the flow within the main pipe.

FIG. **2** is a side view of an injector nozzle and main pipe arrangement depicting a counter-current injection arrangement of the injector nozzle with the flow within the main pipe.

FIG. **3** is a perspective view of the injector nozzle removed from the main pipe, with the injector nozzle end cap removed.

FIG. **4** is an enlarged side view of an injector nozzle and main pipe arrangement depicting a co-current injection arrangement of the injector nozzle with the flow within the main pipe.

FIG. **5** is an enlarged side view of an injector nozzle and main pipe arrangement depicting a co-current injection arrangement of the injector nozzle with the flow within the main pipe.

FIG. **6** is an enlarged side view of an injector nozzle and main pipe arrangement depicting dimension variables of the injector nozzle.

FIG. **7** is an enlarged side view of an injector nozzle and main pipe arrangement depicting dimension variables of the injector nozzle.

FIG. **8**A is a perspective view of the injector nozzle depicting how a longitudinal baffle divides the fluid to a first baffle flow and a second baffle flow, each flow exiting via a different size opening in the injector nozzle.

FIG. **8**B is a perspective view of the injector nozzle depicting how a longitudinal baffle divides the fluid to a first baffle flow and a second baffle flow, each flow exiting via a different size opening in the injector nozzle.

FIG. **8**C is a perspective view of the injector nozzle depicting how a longitudinal baffle divides the fluid to a first baffle flow and a second baffle flow, each flow exiting via a different size opening in the injector nozzle.

FIG. 9A is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a double quench with a 70:30 injector nozzle outlet area.

FIG. 9B is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a double quench with a 60:40 injector nozzle outlet area.

FIG. 9C is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a double quench with a 50:50 injector nozzle outlet area.

FIG. 10A is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a half quench with a 70:30 injector nozzle outlet area.

FIG. 10B is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a half quench with a 60:40 injector nozzle outlet area.

FIG. 10C is a thermal profile within the main pipe depicting temperatures around the injector nozzle during a half quench with a 50:50 injector nozzle outlet area.

FIG. 10D is a cross-sectional thermal contour plot of main pipe taken immediately downstream of the injector pipe.

FIG. 11 is a graph depicting normalized temperature standard deviation versus the number of pipe diameters downstream from the injector nozzle that such temperatures are measured, for a double quench flow rate.

FIG. 12 is a graph depicting normalized temperature standard deviation versus the number of pipe diameters downstream from the injector nozzle that such temperatures are measured, for a half quench flow rate.

FIG. 13 is a flowchart of an example quenching process in accordance with the disclosure.

DETAILED DESCRIPTION

Turning now to the detailed description of the preferred arrangement or arrangements of the present teachings, inventive features and concepts, although presented in conjunction with FIGS. **1-13**, may be manifested in other arrangements and the scope of the invention is not limited to the embodiments described or illustrated. The scope of the invention is intended only to be limited by the scope of the claims that follow.

FIG. **1** and FIG. **2** depict an injection system **10**, which may be used as a quenching system in a quenching process, in which a first hollow pipe, also known as a main pipe **12**, has an outer surface that defines a hole **14** through which a second hollow pipe, also known as an injector pipe **16**, passes so that an end **18** of injector pipe **16** resides proximate a longitudinal centerline **20** of main pipe **12**. Main pipe **12** is referred to as a main pipe because it carries a fluid **22**, such as a vaporous gas, within its hollow portion. The overall diameter of main pipe **12** may be larger than that of injector pipe **16**. Injector pipe **16** may be employed in situations that may include: quenching in-line between hydro-processing reactors, mixing hot vapor bypass fluids into cold fluids from a heat exchanger, mixing cold vapor bypass fluids into hot fluids from a heat exchanger, or mixing at any location where a smaller, primarily vapor stream needs to be mixed into a larger, primarily vapor stream. Using injector pipe **16** during in-line injection of a fluid **26**, which may be a vapor, into a larger diameter pipe **12** into fluid **22**, which may be vapor or a mixed stream such as a liquid and vapor, may occur when there is a relatively large or significant temperature differential, such as greater than 100 degrees Fahrenheit. When there is a temperature differential of 150-200 degrees Fahrenheit, employing an injection system **10** as depicted in FIGS. **1** through **7** may be beneficial, as will be discussed. As depicted in FIG. **1** and FIG. **2** in accordance with the present teachings, a nominal diameter of main pipe **12** is larger than a nominal diameter of injector pipe **16**.

In one example of employing injector pipe **16**, fluid **24** that flows downstream of injector pipe **16** will be cooled to a lower temperature than fluid **22**, which is upstream of injector pipe **16**. However, a challenge of using injector pipe **16** in any injection situation is to ensure that limited cooling or impingement of main pipe **12** occurs during injection. That is, no thermal impingement should occur, such as at interior wall area **28** downstream of injector pipe **16**. A constant or nearly constant temperature at interior wall area **28** of main pipe should be maintained to prevent or limit thermal cycling of material of main pipe **12**. A desired effect accomplished with the present teachings is to promote gradual mixing of the fluid of injector pipe **16** into main pipe **12** that causes a temperature change axially downstream of injector pipe **16** within main pipe **12** without causing undesired, large temperature differentials in main pipe **12**, either axially or radially. Sudden or gross temperature changes in main pipe **12** are avoided with the present teachings.

To eliminate or greatly reduce impingement and its effects on main pipe **12**, from injection by injector pipe **16**, fluid **26** may be divided into a first baffle flow **30** and a second baffle flow **32** by a longitudinal baffle **34**. Within injector pipe **16**, longitudinal baffle **34** may extend past an outlet **36**, also referred to as an opening, of injector pipe **16**. A transverse baffle **38** may be fixed to longitudinal baffle **34** by a weld. When first baffle flow **30** flows along a first side surface **40** of longitudinal baffle **34** and a second baffle flow **32** flows along a second side surface **42** of longitudinal baffle **34**, because transverse baffle **38** is fixed to longitudinal baffle **34**, first baffle flow **30** is directed out of outlet **36** of injector pipe **16** on a first side **40** of transverse baffle **38** and second baffle flow **32** is directed out of outlet **36** of injector pipe **16** on a second side **42** of transverse baffle **38**. Injector pipe **16** may have an end cap **44** to facilitate first baffle flow **30** in being directed completely around a tip end **46** of longitudinal baffle **34** to a first side of transverse baffle **38** to exit via outlet **36**. End cap **44** may be arcuate, curved, or contoured on an interior surface to facilitate smooth flow of first baffle flow **30** of fluid **26** around tip end **46** of longitudinal baffle **34** within injector pipe **16**. End cap **44** may be attached to injector pipe **16** by welding.

FIG. **3** is a perspective view of injector pipe **16** without end cap **44**. As depicted, transverse baffle **38** may be attached to and protrude from longitudinal baffle **34** so that transverse baffle **38** protrudes into outlet **36** and divides outlet **36** into two smaller outlets, a first baffle flow outlet **48** and a second baffle flow outlet **50**. As depicted, transverse baffle **38** may have a curved periphery **54** so that it has the same radius of curvature as an outer surface or curved periphery of injector pipe **16**. An advantage of such a structure may be a more consistent or predictable airflow around and over an exterior surface of injector pipe **16**, whether or not injector pipe **16** is discharging fluid from first baffle flow outlet **48** and a first baffle flow outlet **50**. Also, transverse baffle **38** may have a curved periphery **54** to permit easy insertion into, and removal from, injector pipe **16**. Such insertion and removal may be from an end of injector pipe **16**, such as an end employing end cap **44** with end cap **44** removed (see FIG. **3**), or from the opposite end of main pipe **12** that employs end cap **44**. Flat surface **52** of transverse baffle **38** that faces toward end **18** of injector pipe **16** may form a ninety degree angle with side surface **42** and side surface **40** of longitudinal baffle **34**. Flat surface **52** of transverse baffle **38** may form an angle other than ninety degrees with side surface **42** and side surface **40** of longitudinal baffle **34**. Centering guide **56** and centering guide **58** may be separate pieces or a single piece and may be located at end **18** within injector pipe **16** and may be used to position longitudinal baffle **34** within injector pipe **16**. Similarly, centering guide **60** and centering guide **62** may be separate pieces or a single piece and may be located proximate to an end **66** of injector pipe **16** yet outside of main pipe **12** and may be used to position longitudinal baffle **34** within injector pipe **16**.

FIG. **4** and FIG. **5** are both enlarged side views of injector pipe **16** arranged within main pipe **12** with outlet **36** pointed in a downstream direction relative to fluid **22**, which is an alternate arrangement of injector pipe **16** within main pipe **12**, relative to FIG. **2**. Although, outlet **36** is directed in a co-current arrangement with fluid **22** of main pipe **12**, the structure of injector pipe **16** may be the same as in FIGS. **1** and **2**. That is, first baffle flow **30** and second baffle flow **32** may be divided by longitudinal baffle **34** to cause first baffle flow **30** to strike surface **52** of transverse baffle **38** and second baffle flow **32** to strike a surface **53** of transverse baffle **38**, before both flows **30**, **32** exit via outlet **36**. Longitudinal baffle **34** may be welded to centering guides **56**, **58**, **60**, **62**, which may be welded to an outside wall that defines an outer shell or periphery of injector pipe **16**. Longitudinal baffle **34** has a tip **66** at a first end that resides within a flanged branch **64** that branches from main pipe **12** and surrounds injector pipe **16**.

FIG. **5** depicts how transverse baffle **38** may divide an area of outlet **36** into a two distinct areas, a first baffle flow outlet **68** and a second baffle flow outlet **70**. To produce a desired effect, areas of outlets **68**, **70** may be altered or changed by changing a position of transverse baffle **38** within outlet **36**, whose area effectively equals that of combined areas of outlets **68**, **70**. The area that transverse baffle **38** itself occupies within outlet **36** may be taken into consideration.

FIG. **6** depicts the same view as FIG. **4**, and FIG. **7** depicts the same view as FIG. **5**, except that for both FIGS. **6** and **7**, example dimension variables are displayed, which may be used when employing injection system **10** in accordance with the present teachings. Dimension variables of FIG. **6** and FIG. **7** correspond to those noted below in Table 1 and Table 2. Generally, dimensions are provided for injection tube sizes from nominal 2 inches through 8 inches and sizes of main pipe **12** from nominal 10 inches through 24 inches. Dimensions are applicable to schedule **80** pipe.

In accordance with the present teachings, dimensions of injection system **10** components as depicted in FIGS. **6** and **7** may be in accordance with Table 1, below.

TABLE 1

Layout Dimensions (Schedule 80 Pipe Basis)

Main Nom. Pipe Size, in	ID = D, in	OD, in	Injection Tube Nom. Size, in	l_5, Main ID to CL, in	l_3, Main ID to End of Pipe Cap, in
10	9.562	10.750	2	4.781	7.781
			3	4.781	9.206
			4	4.781	10.561
12	11.750	12.750	2	5.875	8.875
			3	5.875	10.300
			4	5.875	11.655
14	12.500	14.000	2	6.250	9.250
			3	6.250	10.675
			4	6.250	12.030
16	14.312	16.000	2	7.156	10.156
			3	7.156	11.581
			4	7.156	12.936
			5	7.156	14.521
18	16.124	18.000	2	8.062	11.062
			3	8.062	12.487
			4	8.062	13.842
			5	8.062	15.427
			6	8.062	16.887
20	17.938	20.000	2	8.969	11.969
			3	8.969	13.394
			4	8.969	14.749
			5	8.969	16.334
			6	8.969	17.794
24	21.562	24.000	2	10.781	13.781
			3	10.781	15.206
			4	10.781	16.561
			5	10.781	18.146
			6	10.781	19.606
			8	10.781	22.526

In accordance with the present teachings, dimensions of injection system **10** components as depicted in FIGS. **6** and **7** may be in accordance with Table 2, below.

TABLE 2

Injection Tube Dimensions (Schedule 80 Pipe Basis)

D Size, in	W, in	L, in	$l_{1,in}$	$l_{2,in}$
2	1.50	2.00	1.00	15.00
3	2.32	2.85	1.50	16.35
4	3.06	3.76	1.90	17.66
5	3.85	4.73	2.50	19.23
6	4.61	5.65	3.00	20.65
8	6.10	7.49	4.00	23.49

FIGS. **8**A, **8**B and **8**C depict three different size scenarios for first baffle flow outlet **68** and second baffle flow outlet **70**. In order to clearly see interior longitudinal baffle **34** and transverse baffle **38**, FIGS. **8**A, **8**B and **8**C are cutaway perspective views. FIG. **8**A depicts a 70:30 ratio of area of first baffle flow outlet **48** to an area of second baffle flow outlet **50**, FIG. **8**B depicts a 60:40 ratio of area of first baffle flow outlet **48** to an area of second baffle flow outlet **50**, and FIG. **8**C depicts a 50:50 ratio of area of first baffle flow outlet **48** to an area of second baffle flow outlet **50**. Each of the structures of FIGS. **8**A, **8**B and **8**C produce a different result or effect when employed in the current teachings.

FIGS. **9**A, **9**B and **9**C depict results achieved when structures of FIGS. **8**A, **8**B and **8**C are employed, respectively, in a counter-current arrangement, as depicted in FIG. **2**, with injection from injector pipe **16** being set at a double quench rate. A normal or standard quench flow rate may be 9,503 lb/hr, and a double quench rate being discharged from injector pipe **16** into main pipe **12** is, or may be about, 19,006 lb/hr. FIG. **9**A depicts a temperature profile within main pipe **12** when the ratio of area between first baffle flow outlet **48** and second baffle flow outlet **50** is 70:30 or 70% and 30%, respectively. FIG. **9**A depicts an arrangement such that the same constant temperature is maintained at an upstream main pipe wall location **74**, at a downstream main pipe wall location **76**, and at a far-side interior wall location

72 of main pipe 12. Zones 78 are at a significantly cooler temperature than locations 72, 74 and 76, Far-side interior wall location 72 of main pipe 12 is referred to as such because it is a location at an interior wall of main pipe 12 that is opposite or opposed to injector pipe 16. Injector pipe 16 can be thought of passing through its near-side wall. Far-side interior wall location 72 of main pipe 12 is also the closest interior main pipe wall location relative to end cap 44 of injector pipe 16. As depicted in FIGS. 9A, 9B and 9C, a space or gap exists between end cap 44 of injector pipe 16 and far side interior wall location 72. Thus, as depicted in FIG. 9A, the temperatures at locations 72, 74 and 76 are the same or largely the same, which indicates that no thermal impingement of consequence occurs. In other words, thermal impingement is negligible along an interior wall location of main pipe 12 opposite injector pipe 16. Thus, cooling of fluid within main pipe 12 may be achieved, as evidenced by the higher temperature at upstream main pipe wall location 74 and lower temperature at midstream-downstream location 78, while preventing thermal impingement to a large degree along a length of main pipe 12 downstream of injector pipe 16.

FIG. 9B depicts a temperature profile within main pipe 12 when the ratio of area between first baffle flow outlet 48 and second baffle flow outlet 50 is 60:40 or 60% and 40%, respectively. As also depicted in FIG. 9B, a constant temperature is not maintained at an upstream main pipe wall location 74, at a downstream main pipe wall location 76, and at a far-side interior wall location 72 of main pipe 12. More specifically, the temperature at upstream main pipe wall location 74 is higher than the temperature at far-side interior wall location 72. The temperature at far-side interior wall location 72, may be slightly higher than the temperature at downstream main pipe wall location 76 since location 72 is a temperature transition zone. Thus, some thermal impingement occurs when a 60:40 area ratio of outlet 36 is utilized, although such thermal impingement is low and inconsequential. Zone 79 and zone 81 are increasing higher in temperature than zones 78 and similar to or the same as a fluid temperature upstream of injector pipe 16, where no mixing occurs. Thus, impingement is limited to location 72 and location 76, yet prevalent.

FIG. 9C depicts a temperature profile within main pipe 12 when the ratio of area between first baffle flow outlet 68 and second baffle flow outlet 70 is 50:50 or 50% and 50%, respectively. With areas of outlets 68, 70 being equal, as depicted in FIG. 9B, a constant temperature is not maintained at an upstream main pipe wall location 74, at a downstream main pipe wall location 76, and at a far-side interior wall location 72 of main pipe 12. More specifically, the temperature at upstream main pipe wall location 74 is higher than the temperature at far-side interior wall location 72, which appears to be the same or higher to a miniscule degree than the temperature at downstream main pipe wall location 76. Because a constant temperature is not maintained at an upstream main pipe wall location 74, at a downstream main pipe wall location 76, and at a far-side interior wall location 72 of main pipe 12, impingement to a larger degree than in FIGS. 9A and 9B occurs. More specifically, the temperature at upstream main pipe wall location 74 is higher than the temperature at far-side interior wall location 72. The temperature at far-side interior wall location 72 is the same as the temperature at downstream main pipe wall location 76. Thus, thermal impingement occurs when a 50:50 area ratio of outlet 36 is utilized. Zone 79 and zone 81 are increasingly higher in temperature than zones 78 and similar to or the same as a fluid temperature upstream of injector pipe 16, where no mixing occurs. Thus, impingement occurs along main pipe 12 from upstream of location 72 to past location 76.

FIGS. 10A, 10B and 10C depict results achieved when structures of FIGS. 8A, 8B and 8C are employed, respectively, in a half quench rate scenario. A normal or standard quench flow rate is 9,503 lb/hr, and therefore a half quench rate being discharged from injector pipe 16 into main pipe 12 is, or is about, 4,751.50 lb/hr. FIGS. 10A, 10B and 10C each depict temperature contours within main pipe 12 as injector pipe 16 injects cooler fluid into main pipe 12 in a counter-current arrangement. FIG. 10A depicts a temperature profile within main pipe 12 when the ratio of area between first baffle flow outlet 48 and second baffle flow outlet 50 is 70:30 or 70% and 30%, respectively. As depicted in FIG. 10A, a constant, non-quenched temperature is maintained at an upstream main pipe wall location 74, at a downstream main pipe wall location 76, and at a far-side interior wall location 72 of main pipe 12. As depicted in FIGS. 10A, 10B and 10C, a space or gap exists between end cap 44 of injector pipe 16 and far side interior wall location 72. Thus, as depicted in FIG. 10A, the temperature at locations 72, 74 and 76 is the same or largely the same, which indicates that no thermal impingement occurs as a result from an injection discharge from injector pipe 16. Thus, thermal impingement is negligible, along nearly an entire interior wall location of main pipe 12 opposite injector pipe 16. Thus, cooling of fluid within main pipe 12 may be achieved, as evidenced by the higher, non-quench temperature at upstream main pipe wall location 74 and relatively lower temperature at midstream-downstream location 78, while preventing thermal impingement along a length of main pipe 12 downstream and at an opposite side of main pipe 12 as injector pipe 16. Although downstream near side interior zone 80 in FIG. 10A experiences a slightly lower temperature compared to upstream location 74, such lower temperature is not significant enough to amount to a thermal impingement to cause undesirable cyclical thermal fluctuations in material of main pipe 12. Zone 80 is at a higher temperature than zone 78, but both are lower than the unmixed upstream temperature, such as at location 74, which is the same temperature as location 72 and location 76. As an example, a temperature difference between upstream location 74 and downstream, near side interior wall zone 80 may be 25 to 30 degrees Fahrenheit (approximately −4 to −1 degrees Celsius). In FIG. 10A, when the ratio of area between first baffle flow outlet 68 and second baffle flow outlet 70 is 70:30, the temperatures of upstream main pipe wall location 74, far side interior wall location 72, and downstream main pipe wall location 76 may be equal, as they are all depicted in the same temperature zone. Temperature zone 83 may be the same temperature as temperature zone 80.

FIG. 10B depicts a temperature profile within main pipe 12 when the ratio of area between first baffle flow outlet 48 and second baffle flow outlet 50 is 60:40 or 60% and 40%, respectively. As depicted in FIG. 10B, the thermal contours or zones are very similar to the thermal contours of FIG. 10A. That is, a constant temperature contour is maintained at an upstream main pipe wall location 74, at a downstream main pipe wall location 76, and at a far-side interior wall location 72 of main pipe 12. Thus, as depicted in FIG. 10B, the temperature at locations 72, 74 and 76 is the same or largely the same, which indicates that no thermal impingement occurs as a result from a discharge from injector pipe 16. Thus, thermal impingement is negligible, along an entire interior wall location of main pipe 12 opposite injector pipe

16 at location **72** and in near side thermal zone **80**. Thus, cooling of fluid within main pipe **12** may be achieved, as evidenced by the higher temperature at upstream main pipe wall location **74** and lower temperature at midstream-downstream zone **78**, while preventing consequential thermal impingement along a length of main pipe **12** downstream of injector pipe **16**. Although downstream near side interior wall zone **80** in FIG. **10**B experiences a slightly lower temperature compared to upstream location **74**, such lower temperature is not significant enough to amount to a thermal impingement to cause undesirable cyclical thermal fluctuations in main pipe **12**. As an example, a temperature difference between upstream location **74** and downstream, near side interior wall location **80** may be 25 or 30 degrees Fahrenheit (approximately −4 to −1 degrees Celsius). In FIG. **10**B, when the ratio of area between first baffle flow outlet **48** and second baffle flow outlet **50** is 60:40, the temperatures of upstream main pipe wall location **74**, far side interior wall location **72**, and downstream main pipe wall location **76** may be equal, as they are all depicted in the same temperature zone.

FIG. **10**C depicts a temperature contour within main pipe **12** when the ratio of area between first baffle flow outlet **48** and second baffle flow outlet **50** is 50:50 or 50% and 50%, respectively. With areas of outlets **48**, **50** being equal, as depicted in FIG. **8**C, FIG. **10**C depicts how a constant temperature is maintained at an upstream main pipe wall location **74**, at a downstream main pipe wall location **76**, and at a far-side interior wall location **72** of main pipe **12**. Multiple temperature zones exist across a cross section of main pipe **12** downstream from injector pipe **16**, from downstream main pipe wall location **76** to an opposite interior wall temperature zone **84**. As examples, at downstream main pipe wall location **76**, the temperature recorded measured 692 degrees Fahrenheit (367 degrees Celsius). Upon moving toward a center of main pipe **12**, the temperature at downstream temperature zone **78** may be 586 degrees Fahrenheit (308 degrees Celsius). As depicted in FIG. **10**C, downstream temperature zone **78** may be downstream of injector pipe **16** yet inline with openings **48**, **50** (proximate the centerline of main pipe **12**) that open in the upstream direction. The thermal contour continues radially outward downstream from injector pipe **16**, such as from a centerline position of main pipe **12**. Thus, in FIG. **10**C, locations **72**, **74** and **76** within the same zone are at the highest temperature and equal to a temperature of fluid **22** before encountering mixing at injector pipe **16**, temperature zone **84** is next highest in temperature followed by temperature zone **82** and then temperature zone **78**, which is the lowest temperature zone.

FIG. **10**D is a transverse cross-sectional view of main pipe **12** taken at line **10**D-**10**D of FIG. **10**A, for a half quench rate. Injector pipe **16** is depicted with phantom lines in FIG. **10**D to provide perspective of how the thermal plot exists relative to injector pipe **16** when configured with 70:30 area distribution of outlet **36**. Temperature zones **80** indicate a temperature of about 665 degrees Fahrenheit (351 degrees Celsius), temperature zones **82** indicate a temperature of about 532 degrees Fahrenheit (278 degrees Celsius), and far side interior wall location **72** indicates a temperature of about 692 degrees Fahrenheit (367 degrees Celsius). Because the temperature at far side interior wall location **72** is the same as the temperature upstream of injector pipe **16** before mixing, no thermal impingement occurs at far side interior wall location **72**. Because little temperature differential is evident between location **80**, which is 665 degrees Fahrenheit (351 degrees Celsius), and the temperature upstream of injector pipe **16**, which is 692 degrees Fahrenheit (367 degrees Celsius), no significant thermal impingement occurs.

FIG. **11** depicts a graph **85** of normalized temperature standard deviation versus the number of main pipe diameters downstream from injector nozzle **16** that such temperatures were measured. Graph **85** portrays a 70:30 plot **86**, a 60:40 plot **88** and a 50:50 plot **90**, all for double quench flow rates. Plots **86**, **88** and **90** overlay a target box **92**, which is a target box where the standard deviation falls below 2% of the mean within ten diameters downstream of injector pipe **16**. The X-axis is a normalized Z-coordinate that represents the number of diameters of main pipe **12** downstream of injector pipe **16** that a temperature was measured. Target box **92** is a target within which plots are desired to pass through to achieve desired performance results. As depicted, 70:30 plot **86** and 60:40 plot **88** pass through target box **92**, and thus achieve the most advantageous results, while 50:50 plot **90** passes through a corner of target box **92**.

FIG. **12** depicts a graph **94** of normalized temperature standard deviation versus the number of main pipe diameters downstream from injector nozzle **16** that such temperatures were measured. Graph **94** portrays a 70:30 plot **96**, a 60:40 plot **98** and a 50:50 plot **100**, all for half quench flow rates. Plots **96**, **98** and **100** overlay a target box **102**, which is a zone where the standard deviation falls below 2% of the mean within ten diameters downstream of injector pipe **16**. The X-axis is a normalized Z-coordinate that represents the number of diameters of main pipe **12** downstream of injector pipe **16** that a temperature was measured. Target box **102** is a target within which plots are desired to pass through to achieve desired performance results. As depicted, 70:30 plot **96**, 60:40 plot **98** and 50:50 plot **100** pass through target box **92**, and thus achieve advantageous results.

There are multiple advantages of the teachings of the disclosure. One advantage is that by dividing outlet **36** into first baffle flow outlet **68** and second baffle flow outlet **70**, discharges from outlets **48**, **50** impinge each other to facilitate mixing of a relatively colder fluid into a relatively hotter fluid without impinging a wall of main pipe **12**. Because pipe walls will not be impinged or directly struck with a colder fluid, the service life of metal pipes will be increased, and maintenance downtime and replacement costs may be lowered. Injector pipe **16** may perform best in a horizontal or vertically rising portion of main pipe **12**. Fluid **26** of injector pipe **16** may be a single phase or mist to be easily divided and may flow at 75-100 feet per second (23-30 meters per second). 100 feet per second (30 meters per second) may be the maximum flow rate through injector pipe **16**.

The metallurgy of the injector pipe **16** may be adjusted according to service conditions such as temperature, fluid use, etc. Injector pipe **16** may be a minimum of schedule **40** pipe, and may be schedule **80** pipe. Outlet **36** may be centered with longitudinal centerline **20** in main pipe **12** in injection system **10**. Width of outlet **36** may be 80% of the inside diameter of injector pipe **16**, and the length of outlet **36** may be Pi (approximately 3.14) times the width of outlet **36**.

Thus, without sacrificing mixing efficiency, the present teachings impart minimal thermal stresses in main pipe **12** due to minimal impingement of a relatively cold fluid **26** from injector pipe **16** into fluid **22** and interior wall of main pipe **12**. While there may be many injector arrangement scenarios to prevent impingement of a relatively cold fluid **26** from injector pipe **16** against a wall of main pipe **12**, such arrangements have an adverse effect on mixing efficiency when characterized by standard deviation of temperature as a function of downstream distance, as previously explained. In other words, the thermal profiles of other scenarios within main pipe **12** are not advantageous. For example, there are ways to achieve more thorough mixing, but such ways result in direct impingement of a relatively cold fluid within walls of a pipe into which injection is made. The present teachings eliminate or minimize direct thermal impingement without compromising mixing efficiency of a relatively cold fluid **26** from injector pipe **16** into a relatively hotter fluid **22** within main pipe **12**. Another advantage of the injector system of the present teachings is its thermal and mixing effectiveness when injector pipe **16** discharges at different quench rates, which have been previously discussed. Moreover, the present teachings are applicable to vapor injection from injector pipe **16** and two-phase liquid-vapor mixture in main pipe **12**. During analysis, a two-phase mixture in main pipe **12** contained less than 1% liquid by volume when injector pipe injected a 100% vapor stream. Thus, the present teachings are applicable for a vapor-vapor system, that is, from 99%-100% vapor from injector pipe **16** into a 100% vapor stream within main pipe **12**.

Thus, an injection system **10** may include a first hollow pipe **12** for carrying, directing or containing a first fluid, and a second hollow pipe **16** for carrying, directing or containing a second fluid to be injected into first hollow pipe **12**. The second hollow pipe **16** passes through a wall (i.e. hole **14** in the wall) of first hollow pipe **12** to approximately a centerline **20** of first hollow pipe **12**, or past or beyond centerline **20**. Second hollow pipe **16** may have an end cap **44** that protrudes beyond centerline **20** of first hollow pipe **12**. Second hollow pipe **16** may reside through a wall of first hollow pipe **12** with outlet **36** residing proximate a centerline **20** of first hollow pipe **12**. Second hollow pipe **16** may define an outlet in a sidewall to permit the second fluid to flow from second hollow pipe **16** and into the first fluid of first hollow pipe **12**. Longitudinal baffle **34** may reside within second hollow pipe **16**. Longitudinal baffle **34** within second hollow pipe **16** may extend through a sidewall of first hollow pipe **12** to beyond or past centerline **20** of first hollow pipe **12**. Longitudinal baffle **34** may divide the first fluid into a first baffle flow (e.g. a flowing fluid) **30** and a second baffle flow **32** (e.g. a flowing fluid). That is, a first baffle flow (i.e. a fluid flow path) flows along a first side of the longitudinal baffle and the second baffle flow (i.e. a fluid flow path) flows along a second side of the longitudinal baffle. The injection system **10** may further include a transverse baffle **38** that is attached to the longitudinal baffle **34**. Transverse baffle **38** may be arcuate and may protrude into the outlet. The transverse baffle **38** may have a partial peripheral profile that is the same as a peripheral profile of first hollow pipe **12**. Transverse baffle **38** may divide outlet **36** (i.e. the outlet) into a first baffle flow outlet **48** for the first baffle flow and a second baffle flow outlet **50** for the second baffle flow. Transverse baffle **38** may further define two surfaces **52**, **53** that are parallel to each other and that are perpendicular to surfaces **40**, **42** of longitudinal baffle **34**. End cap **44** may enclose a tip end **46** of transverse baffle **38**. First baffle flow **30** may occur between end cap **44** and longitudinal baffle **34**. An area of the first baffle flow outlet **48** may be greater than 50 percent of an area of outlet **36** and an area of the second baffle flow outlet **50** may be less than 50 percent of the area of outlet **36**. Alternatively, an area of the first baffle flow outlet **48** may be 70 percent of the area of outlet **36** and an area of second baffle flow outlet **50** may be 30 percent of the opening. The transverse baffle **38** may have a partial peripheral profile (e.g. an arcuate profile) that may be the same as a peripheral profile (e.g. an arcuate profile) of the first hollow pipe **12**.

A quenching process may include providing a first hollow pipe **12** for containing a first fluid **22** and a second hollow pipe **16** for containing a second fluid **26**. Before dividing any flow, such as the second fluid **26**, the process may include containing the second fluid **26** as a single flow upstream of a longitudinal baffle **34** within the second hollow pipe **16**. The process may then include dividing the second fluid **26** into a first baffle flow **30** along a first side of the longitudinal baffle **34** and a second baffle flow **32** along a second side of the longitudinal baffle **34** within the second hollow pipe **16**. The process may then include directing the first baffle flow **30** from a first baffle flow outlet **48** and the second baffle flow **32** from a second baffle flow outlet **50** in the second hollow pipe **16** and into the first fluid **22** in the first hollow pipe **12**, the first baffle flow outlet **50** having a first baffle flow outlet area and the second baffle flow outlet having a second baffle flow outlet area that together equal a total outlet area.

The quenching process may also include defining a hole **14** in the wall forming first hollow pipe **12**, providing the second hollow pipe **16** through the hole **14** in the wall of the first hollow pipe **12**, and perpendicularly positioning the longitudinal baffle **34** to a longitudinal axis **20** of the first hollow pipe **12**. The process may further include directing the first baffle flow **30** around a tip end **46** of the longitudinal baffle **34**, and not directing the second baffle flow **32** around tip end **46** of the longitudinal baffle **34**. That is, the second baffle flow **34** does not flow around a tip end **46** of the longitudinal baffle **34**.

The quenching process may further include defining an outlet **36** in the second hollow pipe **16**, directing the first baffle flow **30** and the second baffle flow **32** to flow from the second hollow pipe **16** and into the first fluid **22** of the first hollow pipe **12**, providing an end cap **44** over an end **18** of the second hollow pipe **16**, and directing only the first baffle flow **32**, and not the second baffle flow **34**, between the end cap **44** and completely around a tip end **44** of the longitudinal baffle **34**. The quenching process may further comprise defining an outlet **36** in the second hollow pipe **16**, providing a transverse baffle **38** that protrudes into the outlet **36** and that is attached to the longitudinal baffle **34**, and directing the second fluid **34** from the outlet **36** of the second hollow pipe **16** and into the first fluid **26** of the first hollow pipe **12**. The longitudinal baffle **34** within the second hollow pipe **16** may extend through the wall of the first hollow pipe **12** to beyond a centerline **20** of the first hollow pipe **12**.

The quenching process may further comprise defining an outlet **36** in the second hollow pipe **16**, providing a transverse baffle **38** that is attached to the longitudinal baffle **34** and that protrudes into the outlet **36**, directing the first baffle flow **30** and the second baffle flow **32** from the outlet **36** of the second hollow pipe **16** and into the first fluid **22** of the first hollow pipe **12**, defining a hole **14** in the wall of the first hollow pipe **12**, positioning part of the second hollow pipe **16** through the hole **14** in the wall of the first hollow pipe **12** with part of the longitudinal baffle **34** protruding beyond (as depicted in FIG. 1) and perpendicular to a longitudinal axis **20** of the first hollow pipe **12**, defining an outlet **36** in the second hollow pipe **16**, preventing mixing of the first baffle flow **30** and the second baffle flow **32** within the second hollow pipe **16** by providing a transverse baffle **38** that protrudes from the longitudinal baffle **34** and into the outlet **36** of the second hollow pipe **16**, directing only the first baffle flow **30**, and not the second baffle flow **32**, to flow between the end cap **44**, and completely around a tip end **46** of the longitudinal baffle **34**, and directing the first baffle flow **30** and the second baffle flow **32** from the outlet **36** in the second hollow pipe **16** and into the first fluid **22** of the first hollow pipe **12**.

The quenching process may further comprise configuring an area ratio of the first baffle flow outlet area to the second baffle flow outlet area to be 70% to 30%, or configuring an area ratio of the first baffle flow outlet area to the second baffle flow outlet area to be 60% to 40%, or configuring an area ratio of the first baffle flow outlet area to the second baffle flow outlet area to be 50% to 50%.

In another example, with use of flowchart **110**, a quenching process may comprise providing a first hollow pipe **12** (step **112**) defining a first hole **14** in a first hollow pipe sidewall, the first hollow pipe **12** carrying a first fluid, providing a second hollow pipe **16** defining a second hole **36** in a second hollow pipe sidewall, the second hollow pipe **16** protruding through the first hole **14** in the first hollow pipe sidewall (step **114**), the second hollow pipe **16** carrying a second fluid **26** and protruding beyond a longitudinal centerline **24** of the first hollow pipe **12**, providing a longitudinal baffle **34** within the second hollow pipe **16** (step **116**), dividing the second fluid **26** into a first baffle flow **30** along a first side **40** of the longitudinal baffle **34** and a second baffle flow **32** along a second side of the longitudinal baffle **34** (step **118**), and directing the first baffle flow **30** from a first baffle flow outlet **48** and the second baffle flow **32** from a second baffle flow outlet **50** in the second hollow pipe **16** and into the first fluid **26** in the first hollow pipe **12** (step **120**), the first baffle flow outlet **48** having a first baffle flow outlet area and the second baffle flow outlet **50** having a second baffle flow outlet area that together equal a total outlet area.

The quenching process may further comprise preventing mixing of the first baffle flow **30** and the second baffle flow **32** within the second hollow pipe **16** by providing a perpendicular transverse baffle **38** protruding from the longitudinal baffle **34** within the second hollow pipe **16** (steps **122**, **124**), protruding the perpendicular transverse baffle **38** to a level or distance of an exterior surface of the second hollow pipe **16**, positioning a tip end **46** of the longitudinal baffle **34** beyond a center line **20** of the first hollow pipe **12** (step **126**), positioning the second hollow pipe **16** so that the longitudinal centerline **20** of the first hollow pipe **12** is between the transverse baffle **38** and a tip end **46** of the longitudinal baffle **34** (step **128**), providing the transverse baffle **38** with an arcuate profile (step **130**) to permit insertion into the second hollow pipe **16** from an end of the second hollow pipe **16**, and configuring an area ratio of the first baffle flow outlet area to the second baffle flow outlet area to be 70% to 30% of the combined area of the first baffle flow outlet area and the second baffle flow outlet area (step **132**).

In another example, a quenching process may include providing a first hollow pipe **12** for containing a flowing first fluid **22** and a second hollow pipe **16** for containing a flowing second fluid **26**, containing the flowing second fluid **26** as a single flow upstream of a longitudinal baffle **34** within the second hollow pipe **16**, dividing the flowing second fluid **26** into a first baffle flow **30** along a first surface (side) **30** of the longitudinal baffle **34** and a second baffle flow **32** along a second surface (side) **32** of the longitudinal baffle **34** within the second hollow pipe **16**, providing a transverse baffle **38** having two parallel surfaces **52**, **53** that are perpendicular to surfaces **40**, **42** of the longitudinal baffle **34**, the transverse baffle **38** protruding from the longitudinal baffle **34**, and directing the first baffle flow **30** from a first baffle flow outlet **48** and the second baffle flow **32** from a second baffle flow outlet **50** in the second hollow pipe **16** and into the first fluid **22** in the first hollow pipe **12**, the first baffle flow outlet **48** having a first baffle flow outlet area and the second baffle flow outlet having a second baffle flow outlet area that together equal a total outlet area, providing the transverse baffle **38** with an exterior partial peripheral arcuate profile that is geometrically the same arcuate shape as an exterior peripheral profile of the first hollow pipe **12**, and configuring an area of the first baffle flow outlet area to be greater than or equal to an outlet area of the second baffle flow outlet area.

It should be noted that the discussion of any reference is not an admission that it is prior art to the present invention, especially any reference that may have a publication date after the priority date of this application. At the same time, each and every claim below is hereby incorporated into this detailed description or specification as additional embodiments of the present invention.

Although the systems and processes described herein have been described in detail, it should be understood that various changes, substitutions, and alterations can be made without departing from the spirit and scope of the invention as defined by the following claims. Those skilled in the art may be able to study the preferred embodiments and identify other ways to practice the invention that are not exactly as described herein. It is the intent of the inventors that variations and equivalents of the invention are within the scope of the claims while the description, abstract and drawings are not to be used to limit the scope of the invention. The invention is specifically intended to be as broad as the claims below and their equivalents.

The invention claimed is:

1. A quenching process comprising:

providing a first hollow pipe for containing a first fluid and a second hollow pipe for containing a second fluid;

containing the second fluid as a single flow upstream of a longitudinal baffle within the second hollow pipe;

dividing the second fluid into a first baffle flow along a first side of the longitudinal baffle and a second baffle flow along a second side of the longitudinal baffle within the second hollow pipe; and

directing the first baffle flow from a first baffle flow outlet and the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the first fluid in the first hollow pipe, the first baffle flow outlet having a first baffle flow outlet area and the second baffle flow outlet having a second baffle flow outlet area that together equal a total outlet area, wherein the first and second baffle flow outlets are configured to have an area ratio between them such that the area of the first baffle flow outlet is about 60% to about 70% of the total area and the second baffle flow outlet makes up the difference or is about 40% to about 30% of the total area.

2. The quenching process according to claim **1**, further comprising:

defining a hole in a wall of the first hollow pipe;

providing the second hollow pipe through the hole in the wall of the first hollow pipe; and

perpendicularly positioning the longitudinal baffle to a longitudinal axis of the first hollow pipe.

3. The quenching process according to claim **1**, further comprising:

directing the first baffle flow around an end of the longitudinal baffle; and

not directing the second baffle flow around an end of the longitudinal baffle.

4. The quenching process according to claim 3, further comprising:

defining an outlet in the second hollow pipe; and

directing the first baffle flow and the second baffle flow to flow from the second hollow pipe and into the first fluid of the first hollow pipe.

5. The quenching process according to claim 1, further comprising:

providing an end cap over an end of the second hollow pipe; and

directing only the first baffle flow, and not the second baffle flow, between the end cap and completely around a tip end of the longitudinal baffle.

6. The quenching process according to claim 1, further comprising:

defining an outlet in the second hollow pipe;

providing a transverse baffle that protrudes into the outlet of the second hollow pipe and that is attached to the longitudinal baffle; and

directing the second fluid from the outlet of the second hollow pipe and into the first fluid of the first hollow pipe.

7. The quenching process according to claim 1, wherein the longitudinal baffle within the second hollow pipe extends through a wall of the first hollow pipe to beyond a centerline of the first hollow pipe.

8. The quenching process according to claim 1, further comprising:

defining an outlet in the second hollow pipe;

providing a transverse baffle that is attached to the longitudinal baffle and that protrudes into the outlet; and

directing the first baffle flow and the second baffle flow from the outlet of the second hollow pipe and into the first fluid of the first hollow pipe.

9. The quenching process according to claim 1, further comprising:

defining a hole in a wall of the first hollow pipe;

positioning part of the second hollow pipe through the hole in the wall of the first hollow pipe with part of the longitudinal baffle protruding beyond and perpendicular to a longitudinal axis of the first hollow pipe;

defining an outlet in the second hollow pipe;

preventing mixing of the first baffle flow and the second baffle flow within the second hollow pipe by providing a transverse baffle that protrudes from the longitudinal baffle and into the outlet of the second hollow pipe;

directing only the first baffle flow, and not the second baffle flow, to flow between an end cap and completely around a tip end of the longitudinal baffle; and

directing the first baffle flow and the second baffle flow from the outlet in the second hollow pipe and into the first fluid of the first hollow pipe.

10. A quenching process comprising:

providing a first hollow pipe defining a first hole in a first hollow pipe sidewall, the first hollow pipe carrying a first fluid;

providing a second hollow pipe defining a second hole in a second hollow pipe sidewall, the second hollow pipe protruding through the first hole in the first hollow pipe sidewall, the second hollow pipe carrying a second fluid and protruding beyond a longitudinal centerline of the first hollow pipe;

providing a longitudinal baffle within the second hollow pipe;

dividing the second fluid into a first baffle flow along a first side of the longitudinal baffle and a second baffle flow along a second side of the longitudinal baffle; and

directing the first baffle flow from a first baffle flow outlet and the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the first fluid in the first hollow pipe, the first baffle flow outlet having a first baffle flow outlet area and the second baffle flow outlet having a second baffle flow outlet area that together equal a total outlet area, wherein mixing of the first baffle flow and the second baffle flow is prevented within the second hollow pipe by providing a perpendicular transverse baffle protruding from the longitudinal baffle within the second hollow pipe, the perpendicular transverse baffle is arranged to protrude to an exterior surface of the second hollow pipe, a tip end of the longitudinal baffle is positioned beyond a center line of the first hollow pipe, the second hollow pipe is positioned so that the longitudinal centerline of the first hollow pipe is between the transverse baffle and a tip end of the longitudinal baffle, the transverse baffle is provided with an arcuate profile to permit insertion into the second hollow pipe from an end of the second hollow pipe, and an area ratio of the first baffle flow outlet area to the second baffle flow outlet area is configured to be about 70% to about 30%.

11. A quenching process comprising:

providing a first hollow pipe for containing a flowing first fluid and a second hollow pipe for containing a flowing second fluid;

containing the flowing second fluid as a single flow upstream of a longitudinal baffle within the second hollow pipe;

dividing the flowing second fluid into a first baffle flow along a first side of the longitudinal baffle and a second baffle flow along a second side of the longitudinal baffle within the second hollow pipe;

providing a transverse baffle having two parallel surfaces that are perpendicular to surfaces of the longitudinal baffle, the transverse baffle protruding from the longitudinal baffle; and

directing the first baffle flow from a first baffle flow outlet and the second baffle flow from a second baffle flow outlet in the second hollow pipe and into the first fluid in the first hollow pipe, the first baffle flow outlet having a first baffle flow outlet area and the second baffle flow outlet having a second baffle flow outlet area that together equal a total outlet area, wherein the first and second baffle flow outlets are configured to have an area ratio between them such that the area of the first baffle flow outlet is about 60% to about 70% of the total area and the second baffle flow outlet makes up the difference or is about 40% to about 30% of the total area.

12. The quenching process according to claim 11, further comprising:

providing the transverse baffle with an exterior partial peripheral profile that has a same arcuate shape as a peripheral profile of the first hollow pipe.

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